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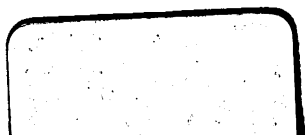
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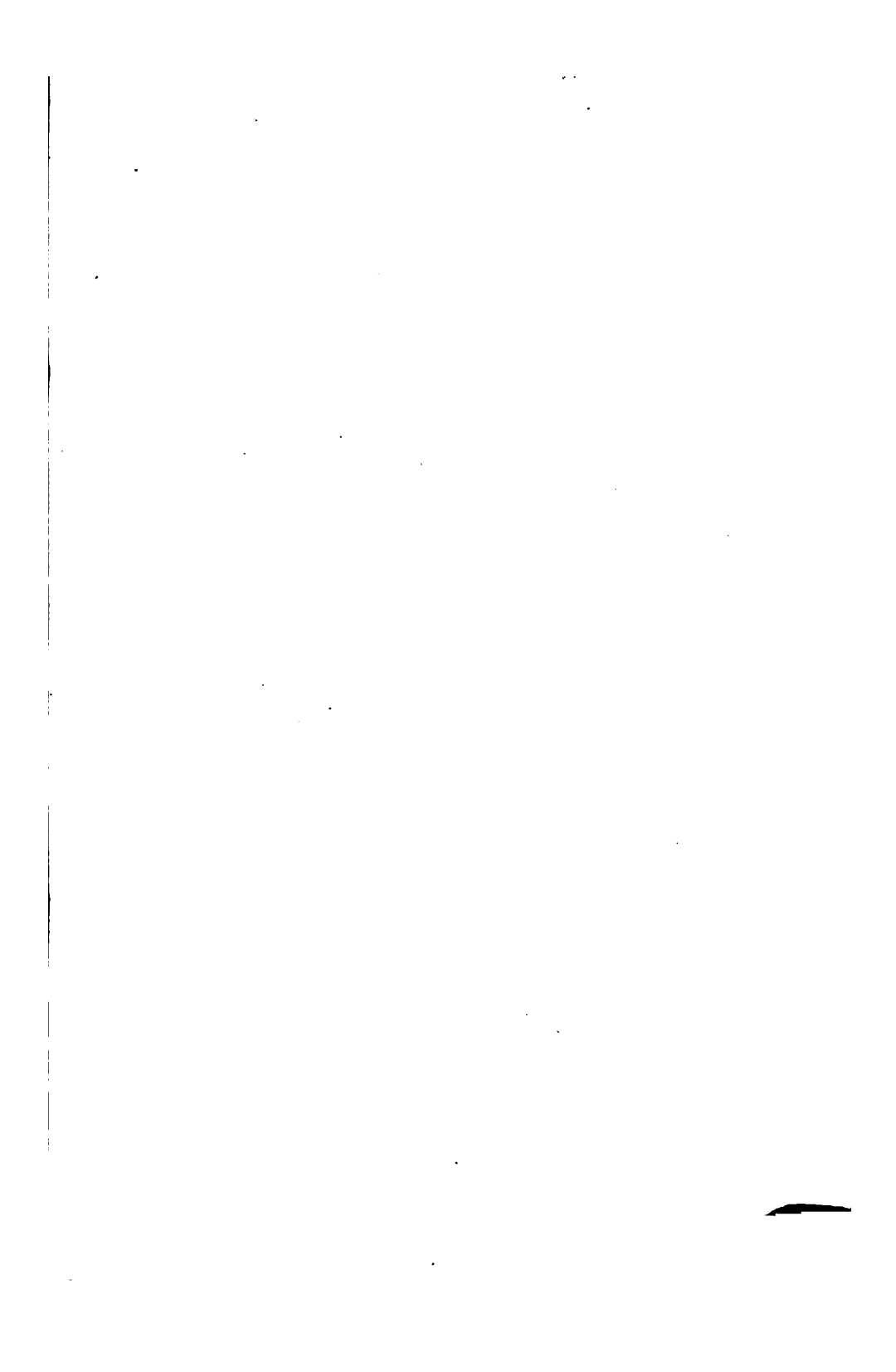
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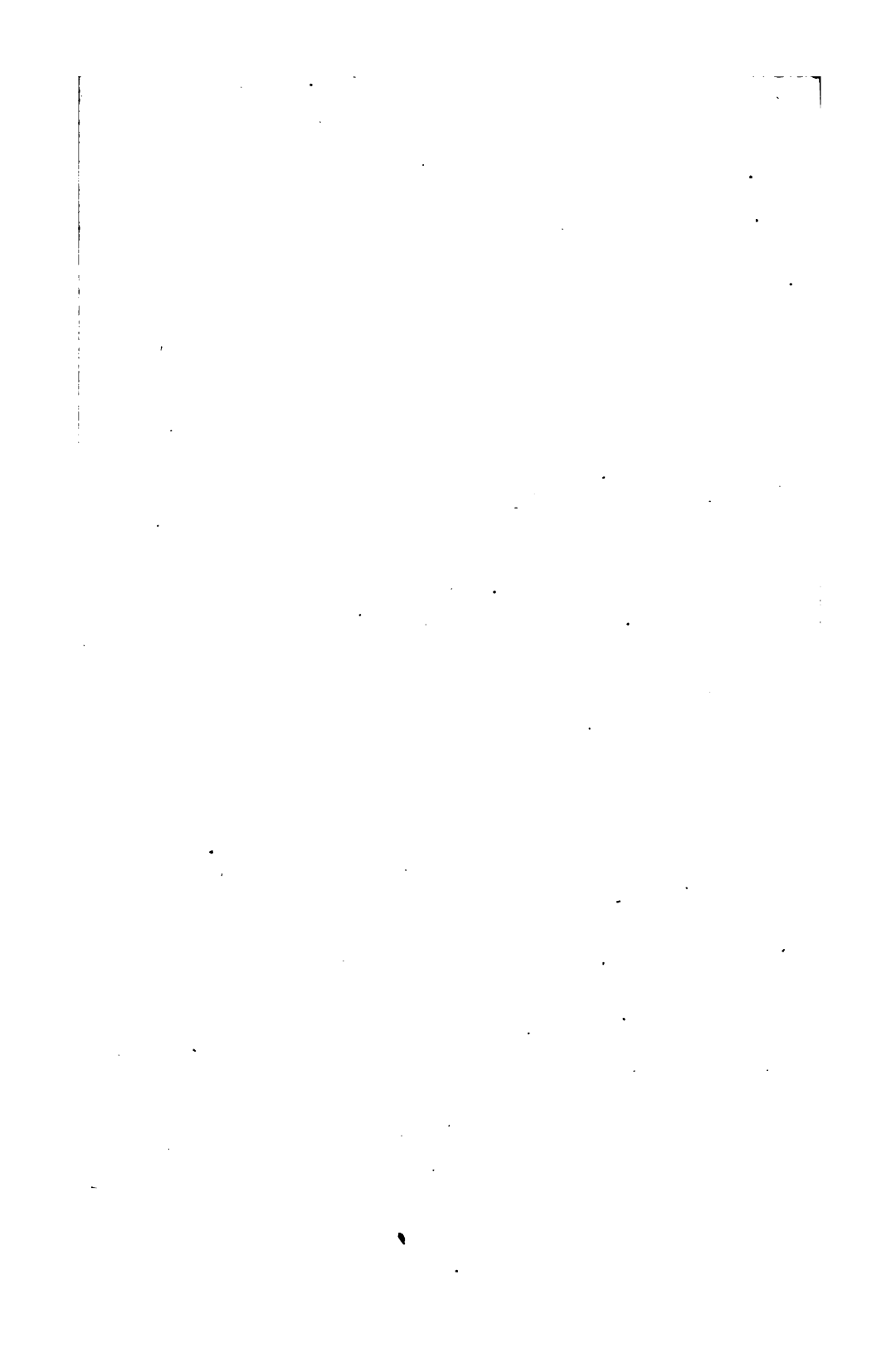
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ALASTOR
OR THE
NEW PTOLEMY





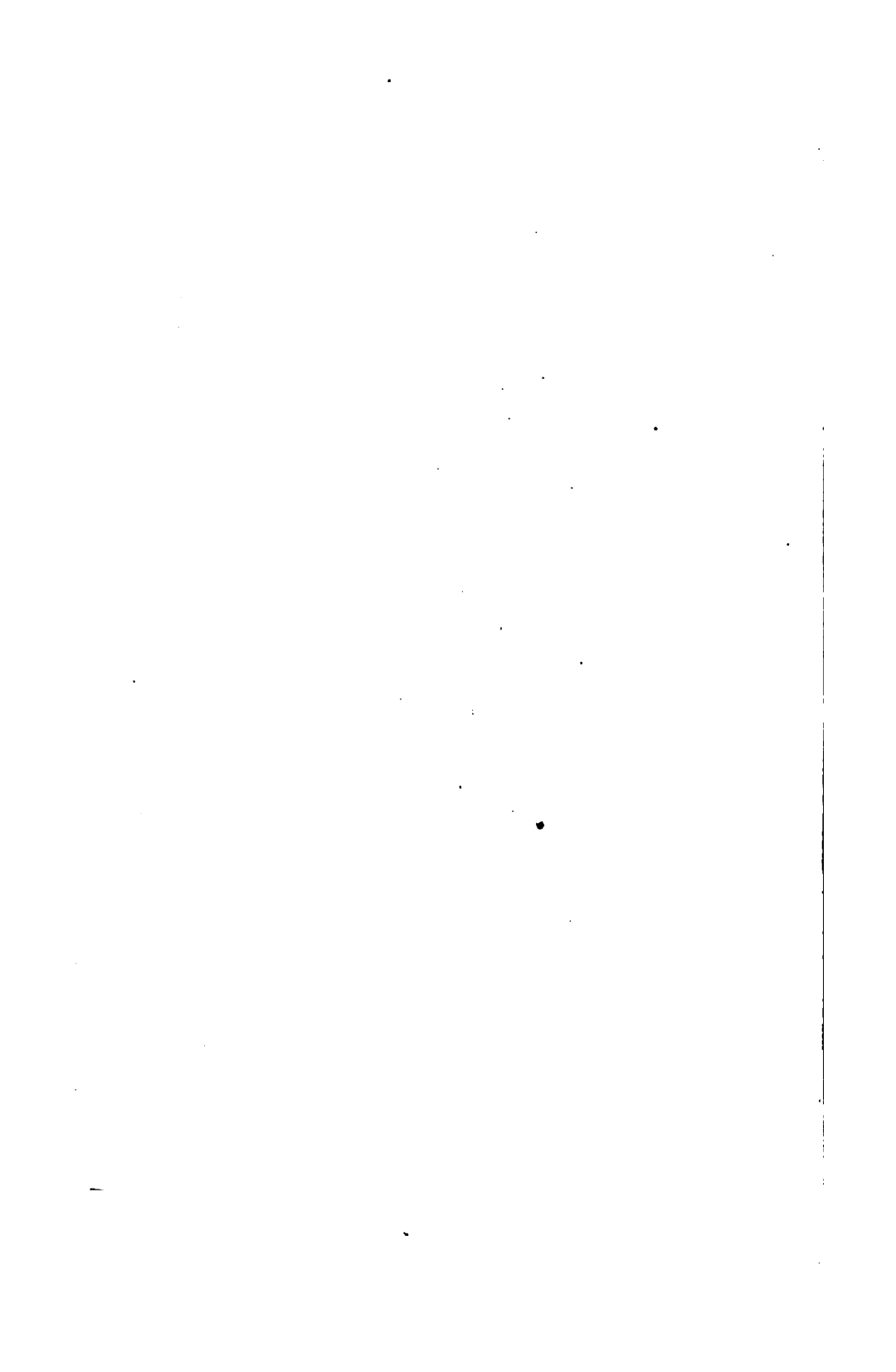


ALASTOR:

OR,

THE NEW PTOLEMY.

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ALASTOR:

OR,

THE NEW PTOLEMY.

"Nominibus differentes, re congruentes."

CICERO, Acad. Quest. II. 5.

LONDON

SAUNDERS AND OTLEY, CONDUIT STREET.

1852.

184. G. 15.



ALASTOR;
OR,
THE NEW PTOLEMY.

I.

All Souls' Gardens, Oxford.

ALASTOR AND DION.

ALASTOR. Allow that you have nothing equal to these our gardens; not even the never-to-be-forgotten willow at Clare Hall?

DION. There is nothing equal to these gardens now at Cambridge, certainly: nor anything here either that would tempt me to remain, like you, in vacation time.

ALASTOR. I feel the compliment of your visit all the more; but I assure you, if you wish to read to any purpose, this is the time. Now, when these

quiet walks seem, more nearly than anything else of modern days, to realize old Academe's sweet shades.

DION. Your purpose-like reading is, I suppose, just everything you fancy.

ALASTOR. That is the advantage of Oxford—to me at least—what I fancy are the prescribed studies of the place. I was, when you came in this morning, at Thucydides—quite naturally and genuinely—I had nobody to admire me, and certainly could not foresee your interrupting me. While, on the contrary, if I had surprised you at Trinity, in vacation, or, ay, even in term time, I might have found you with a little green volume, with Bruxelles on the outside—a George Sand, or an Eugene Sue, in fact.

DION. Not from distaste for the Cambridge course, but merely to refresh my eyes, and relieve my mind from the strain of severer studies! Seriously, it is one of the merits of being occupied by the exact sciences, your mind is forced to exert itself, and enjoys the refreshment of rest.

ALASTOR. *Exact sciences.* Now, do just tell me what are the exact sciences. Taking the range of human knowledge for science generally—which are those more especially exact?

DION. Mechanics, chemistry, and, above all, mathematics, are always called exact, because they

depend upon observation and experiment, and the eternal harmony of calculation.

ALASTOR. But Philosophy—not natural : philosophy no longer allowed to be a science ; philosophy applied only to the processes of the mind ; and history, the interest which men feel in the past ; and poetry, which belongs to past, present, and future ;—all these are branded as inexact—what is exact ?

DION. That which is proved to a fixed point of evidenced truth.

ALASTOR. Well, I do not think your definition very good, even for your own purpose ; but let us look at these fixed truths. Mechanics : Here are the mechanical powers : your definators have not even agreed how many powers you have. Some are for having lever, screw, inclined plane, and pulley, while others reduce all into one—the lever.

DION. These are very trite distinctions.

ALASTOR. Yet twenty years ago these distinctions were considered a part of the exactness of this exact science.

DION. All science is advancing : the more exact the greater the progress ; one step firmly established, we proceed to another, as I defined it—proved to a fixed point.

ALASTOR. Fixed only to be removed next gene-

ration. However, for exactness' sake, how many powers is mechanics blessed with to-day ?

DION. In the advanced state of the science of dynamics, we——

ALASTOR. Her very name obsolete ! I beg her pardon. You see how wretchedly behindhand I am in even the nomenclature of these exact sciences, which change as often as the fashions in the "Ladies' Newspaper."

DION. Your idea of science is certainly a very limited and slavish one : you think that exactness is final, that progress is change ; you want, when you have reached a conviction, to stand still, and attempt nothing more.

ALASTOR. Not at all. I am ready to go as fast and as far as you please ; I only want some sort of a staff to lean on, or some granitic formation to build upon. I only want to know where the exactness is.

DION. That, so far as we have yet attained, all is proved by observation and demonstration.

ALASTOR. By observation, we perceive a windlass draws up a sack of corn to the top of the mill more easily than it would be carried ; by observation, we perceive that different combinations of various substances produce various different colours and tastes in chemical processes. By observation,

we are quite aware of the difference between night and day—and now for the demonstration.

DION. By demonstration, the coarsest and rudest observation of the commonest and most obvious operations in mechanics, chemistry, and astronomy, such as you have chosen, may be reduced to the subtlest and most delicate proofs by that science which is at once the loftiest and the most exact.

ALASTOR. Mathematics? Is that still the name? For want of a better, you still, I suppose, include in this name all the varieties of geometry and algebra, and so forth. This lofty and subtle science is to prove, by demonstration, what we are quite sure of by the conviction of our observation. But how is this? Is it a mistake of mine? Did I misread the passage—a passage from Sir John Herschel's "Natural Philosophy," I think to this effect—

DION. No, no, I will not admit quotations "to this effect" from a scientific book. A pretty way you would be in if you gave a false quantity in a citation from Sophocles at examination!

ALASTOR. To be sure I should, because that is exact, that is a fixed science; there is no doubt about the fact; you cannot *approximate* in a verse, it must be complete; you cannot say it is so many words, *nearly*. You cannot give a line from Horace,

with a word or two omitted, and tell your tutor it is, "if any one take the trouble to go through the process, *almost*" such and such and such numbers, as Sir John Herschel says. No, the line must be the line, or not at all.

DION. So must the quotation. But you must find this sentence of Herschel's.

ALASTOR. I will show you the very words when we go in, for this last quotation is only at second-hand. This I saw in Humboldt's "Cosmos;" which, little as you think of my taste in such matters, I have been reading with the very greatest interest and pleasure. So eloquent, so enthusiastic, so sublime!—he really seems to look from some supermundane height and scan the worlds below, and call about him all the powers of human thought, and, at his bidding, show them forth in their supremacy.

DION. It is the grandest monument that living genius ever raised to itself; but though there is everything that is known—though it is "Cosmos"—the assemblage of all that man has done—yet it is only assemblage; it is only a set of tableaux; it can hardly be called a living drama of science. There is no *moral* developed. You learn immensely in every page, but I think one feels at the end that one does not know what to do with one's learning; or rather, one feels a want of

knowing what the author means us to do with it.

ALASTOR. I hardly feel that. Humboldt says, in his preface:—"The aspect of external nature, as it presents itself in its generality to thoughtful contemplation, is that of unity in diversity, and of connexion, resemblance, and order among created things most dissimilar in their form—one fair harmonious whole. To seize this unity and this harmony amid such an immense assemblage of objects and forces—to embrace alike the discoveries of the earliest ages and those of our own time—and to analyze the details of phenomena without sinking under their mass, are efforts of reason in that path wherein it is given to man to press towards the full comprehension of nature; to unveil a portion of her secrets, and, by the force of thought, to subject, so to speak, to his intellectual dominion, the rough materials which he collects by observation." This is what he proposes to himself—this is what is so admirable in the book. It is, as he says, a showing forth of the intellectual dominion of man over the mere material of nature. It is looking upon this material, nature, not as the mere assemblage of organized or unorganized combinations, but as each particular part necessary to every other; imperfect, perhaps, in itself, or imperfect if imper-

fectly viewed; yet, in its relation to every other particular part and to the whole, forming a perfect combination—that “unity in diversity,” which gathers every isolated, every disjointed, every obscure or individual fact, and draws it, with an irresistible force, into the one centre sense of a mighty whole. Viewing all this as a man—looking at it with human means, reflecting upon it with human intellect, combining the parts and concentrating the whole to the level of human thought—the highest level, the most lofty elevation—the most exalted force of human intellect, but still only human; that is, finite, limited, and restricted within those bounds which it can never pass. It is the very absence of attempts to theorize which makes the excellence of this book. The dignity of the position in which the writer places himself and his readers, or rather the dignity of the point of view at which he places human powers, is the charm and the supremacy of the book. The true dignity of knowing what and where we are is not only noble in itself but endues us with a force and a tenacity of purpose in our acquirements in the phenomena of the past, and for investigation of the present, and which falls powerless when still, ever but human, we arrogate the right divine, and pretend, with sacrilegious hands and with blaspheming words, to

build anew the lofty structure we behold; and while we scarcely comprehend the visible, dare profanely to rend that veil we cannot raise, and then, phrenetic, we pronounce upon the purposes and the designs of the Almighty mystery—the source of what we try to comprehend.

DION. Experimental philosophy with a vengeance! You would have nothing but bare facts! Never a theory to put them together by!

ALASTOR. Cannot we combine into a system without presuming to theorize? “Cosmos” is not a mass of undigested facts; they are artistically grouped; they are so lucidly arranged, they fall into their appointed posts with such disciplined readiness, that they are at once fixed and living in our memories.

DION. How very well the book is translated. It reads as an original.

ALASTOR. Yes, there are passages of such infinite beauty one can hardly suppose them the worse for not being in their original, which I have never seen. But it is a pity that, when the translator took such admirable pains with the work, and rather rewrote it, as Humboldt, had he been English, would have written, than merely put out of German into English words—it is a pity that so many barbarous Græco-German technicalities were left.

DION. These Greek technicalities are what the German scientific writers so particularly pride themselves upon.

ALASTOR. Let us leave them to the Germans, then. Why should we go back to obsolete superstitions in this mythology of nomenclature? We cling to time-honoured forms, and we revere such words and names as great men's use has hallowed to our sense; but we stumble and shy from the laborious combinations which, without much grammar, are culled out of a Greek or Latin vocabulary, and put together to express what plain English or German could have told us just as well. We should be justly shocked at any retrospective reformer who should substitute some Germanised or Anglicised form of name for Jupiter or Juno, or any of our old friends of the Pantheon, or who should fancy to talk of a heat-gauge instead of a thermometer. But is not it just as absurd to give us now these chance-medley feasts from the alms-basket of all languages?

DION. You would, then, have *earthy*, instead of *telluric*—*occasional*, or *scattered*, instead of *sporadic*, and so on; but would English, after all, be as comprehensive, or, in the end, as comprehensible?

ALASTOR. You show that you have had to put

them into English; why should not they have been printed so at once?

DION. But what German in the original, or what English in the translation, could you have had instead of "Cosmos?"

ALASTOR. A title of a book is like a man's name—we take it at once to mean that book; we have not to stop in a sentence to satisfy ourselves with the meaning of the word before us. We know that Paul, or Julia, or Alfred, or Emma, mean such and such men and women, and we do not trouble ourselves about their Greek, Latin, or Saxon derivation; and we take Lycidas or Cosmos as the names of poems or of books, and never think of going back to make out why they are called so.

II.

ALASTOR. Here, under this shade, in the sacred stillness of noontide——

DION. Let me see your reference now.

ALASTOR. Here it is:—

“Were our mathematics perfect, and all the data known. Unhappily the first is so far from being the case, that in many of the most interesting dynamical inquiries, they leave us completely at a loss. We can (in the motions of fluids) include our problems in algebraical equations, and we can demonstrate that they contain the solutions; but the equations themselves are so intractable, and present such insuperable difficulties, that they often leave us quite as much in the dark as before.”

Now work out this problem in Geometrical Analysis:—

“Given in magnitude and position the base of a triangle, and the ratio of the sides: to determine the locus of the vertex.”

DION. Well, this is the result:—The bisectors CD and CD' form a right angle at C , and therefore the point C must be placed upon a circle whose diameter is DD' —which circle is the locus of the

vertex of the triangle, the base of which in magnitude and position was given with the ratio of the sides.

ALASTOR. You are right; but mark the note—
“As there are two points D at which the line may be divided in the given ratio, and as it may be produced at either end: the locus, strictly speaking, is two circles.”

And again—“Given the base of a triangle: the sum of the squares of the sides and the vertical angle: to construct the triangle.”

Now, construct.

DION. If we have the base and the sum of the squares of the sides—let me look at the former proposition. Yes; I find by one the *locus* of the vertex, and by another: as in your problem the base and the vertical angle are given: I find the intersection of these loci to be the *determination* of the vertex.

ALASTOR. Not so determinate, for, as the demonstrator says, “It may happen that the loci do not intersect. In this case the solution is impossible, and the data are inconsistent.”

DION. He should have said, that the solution is impossible, *because* the data are inconsistent.

ALASTOR. And he goes on—“When the loci do not meet, the problem is impossible, and the data contradictory. And when they become identical,

the problem is indeterminate, and the data not independent."

DION. That will appear as you work it, and is to be allowed for, of course.

ALASTOR. Of course; that is all I meant to show—that the result was *indeterminate*, and that there was an *allowance* to be made. I am not cavilling at the mode or at the truth of the working out—I merely give these as proofs of my assertion, that EXACTNESS is not a proper term applied to mathematical reasoning. Take another example from De Morgan—"All the formulæ to which we have hitherto been led are perplexing to calculate for moderate numbers, and absolutely out of the question for high numbers. We now come to the part of our subject which may be considered as the most important of the whole, being the most difficult of the indispensable considerations—namely, the approximation to functions of very high numbers. But we have first to consider the species of expressions which have been hitherto obtained. And here we cannot have avoided observing, that in every case variable products have been obtained, in which one of the variables is the number of factors, which varies in a manner depending upon the number of events in question."

Here we find, that after long and laborious cal-

culations the products are variable, and that when all is done, the numbers capable of being worked upon are limited, and that the *most important part of the whole*, the *indispensable* consideration, is at last only an *approximation*.

DION. Observe, however, that this is in the Theory of Probabilities, where the result is obtained by the elaboration of uncertainties.

ALASTOR. Where the end is as uncertain as the beginning; for here is one of the last sentences of the essay:—"If the number n be extremely great, the result of the preceding is very nearly the product, p , p . 2, p . 3. . . . p . r ." If the number be *extremely* great—what is *extremely*? Can there be anything more loose and vague than this statement? and equally so the result. "The product," he says, "is *very nearly*" so and so. VERY NEARLY is at last what we arrive at, at the end of 473 closely printed quarto pages, stuffed with the most laborious calculations.

DION. But, as I said before, in a theory of probabilities the result can only be a probability.

ALASTOR. Yes, just so; "it is a contradiction in terms to call it a theory." I was struck with this observation in some magazine; and the more I have considered it, the more I have been impressed with the vagueness and inexactness of this attempt to theorize what is in its essence incapable of de-

monstration; but here is another specimen of your exact sciences.

"Now, although it is true that the mean motions of no two planets are exactly commensurate; yet cases are not wanting in which there exists an approach to this adjustment; and in particular in the case of Jupiter and Saturn. That cycle we have taken for our example in the above reasoning—viz., a cycle composed of five periods of Jupiter, and two of Saturn—although it does not exactly bring about the same configuration, does so pretty nearly."*

Pretty nearly!—your exact science!

"Now," says Sir J. Herschel, speaking† of the orbits of the planets; "now, it may naturally be inquired whether in the vast cycle above spoken of, in which, at some period or other, conspiring changes may accumulate on the orbit of one planet from several quarters: it may not happen that the eccentricity of any one planet, as the Earth, may become exorbitantly great, so as to subvert those relations which render it habitable to man, or to give rise to great changes at least in the physical comfort of his state. To this the researches of geometers have enabled us to answer in the negative. A relation has been demonstrated by

* Herschel's "Treatise on Astronomy," p. 346. † Ibid. 369.

Lagrange between the masses, axes of the orbits, and eccentricities of each planet, similar to what we have already stated with respect to their inclination—viz., ‘*that if the mass of each planet be multiplied by the square root of the axis of its orbit, and the product by the square of its eccentricity; the sum of all such products throughout the system is invariable.*’ And as, in point of fact, this sum is extremely small, so it will always remain.”

Here are two of the greatest men in the EXACT sciences, and the result of their reasoning is this expression: “this sum is extremely small.” Extremely small!—small in proportion to what? Small is an adjective: it must be relative to something. Is it here a relative in proportion to size or to number, to space or to force? “The mass of each planet,”—the mass, as represented by weight in numbers? Or, what is the mass of a planet which is to be multiplied by the square root of the axis of its orbit, of which the product being multiplied by the square of the eccentricity: *the sum of all such products* is invariable in all the systems of the universe. The sum of what? Is the weight and size—the orbit or the eccentricity of all planets—the same? And if not, how can multiplying the square roots and the masses arrive at the same result? Or what is meant by “the sum of

all such products?" The sum means the total in addition; then the sum of the products means all the products of these multiplied masses, orbits, and eccentricities added together. If the same products—and he says, "of all such products"—if all the products are added together, what difference of result could there be? If they are different, how can the sum be the same?

DION. What you are objecting to is Lagrange's theory; and is perhaps mis-stated. Have you Lagrange?

ALASTOR. I have not: but I wish you would get it and verify the quotation. Not that it makes any difference in my argument, for Sir John Herschel's reasoning upon it is equally inexact, whether he has quoted accurately, or inaccurately. I object to his expression "extremely small;" it is unphilosophical, and though it may do very well in what are *called* the exact sciences, it is, to an accurate reasoner, an absurdity—a mere expression—a meaningless set of words.

DION. Go on, will you—finish the section: extracts are scarcely a fair way of testing the accuracy of scientific investigation.

ALASTOR. My extract is perfectly fair; it begins, if you observe, at the starting of the difficulty, and goes on word for word from the original, to what is intended to be the solution of it.

DION. It is not, however, possible to test the accuracy of such demonstrations without going through the processes; if we do not do so, we must take the assertion on trust.

ALASTOR. I will not take any assertion on trust which is inconsistent with itself; but I will go on with the extract. I ended with—"as in point of fact this sum is extremely small, so it will always remain." He goes on—"now, since the axis of the orbits are subject to no secular changes, this is equivalent to saying that no one orbit shall increase its eccentricity unless at the expense of a common fund, the whole amount of which is, and must ever remain extremely minute." To which he appends this note, "There is nothing in this relation, however, taken *per se*, to secure the smaller planets—Mercury, Mars, Juno, Ceres, &c., from a catastrophe, could they accumulate on themselves, or any one of them, the whole amount of the *eccentricity fund*. But, that can never be; Jupiter and Saturn will always retain the lion's share of it. A similar remark applies to the *inclination fund* of article 515. These *funds*, be it observed, can never get into debt. Every term of them is essentially positive."

DION. You should not condemn as inaccurate such illustrations as these, which are meant, in a popular work like this, rather to outline and make

familiar the general views of astronomy, than to perplex unscientific readers with minutiae of mathematical reasoning.

ALASTOR. Why, then, the author should not enter into any minutiae. If a demonstration, such as he quotes from Lagrange, is given, it should be given accurately; and, as I said before, this demonstration is nought; for, as his after observations show, the sum of these products means that all the products of all the multiplication of the masses, orbits, and eccentricities, or of their square roots—being added together, they will come to the same sum: and what does that prove? Or, what does his note prove?

DION. However, in a work intended for general readers, you cannot expect the same hardness of close mathematical method that would be necessary in a treatise intended for men of mathematical knowledge. As Sir John Herschel says, in his "Essay on Natural Philosophy," "A certain moderate degree of acquaintance with abstract science is highly desirable to one who would make any considerable progress in physics." *

ALASTOR. As moderate as you will, but that knowledge, however moderate, should be accurate. And propositions stated in a work intended for common, and not for scientific readers, should be,

* Essay on "Natural Philosophy," p. 19.

as far as it goes, accurate and intelligible; now, either the passage I have just quoted is unintelligible, or it is inaccurate.

DION. Simple numbers multiplied and added in this way (though Herschel in this Essay says, that number is the soul of accuracy) are not any criterion for the nicer operations of mathematical scrutiny.

ALASTOR. Of course; but still two and two are four; and multiplication is multiplication; and while the word "product" and "sum" are used, they are, unless otherwise explained and understood, to mean the result of operations, whether algebraical or arithmetical, of multiplication and addition. But let us leave these popular, and therefore you suppose allowably inaccurate treatises, and go to one by Sir John Herschel, written for a Cyclopædia, the article in the "Metropolitana" on "Light."

After a series of elaborate calculations, he arrives at the "Case of a wave transmitted through a limited aperture," from which he deduces this corollary; "If but a *very small* portion of the wave be permitted to pass, as in the case of a ray transmitted through a *very small* side, and received on a *distant* skreen, θ and $\varphi(\theta)$ are *very nearly* constant, so that the motion excited in χ is in this case represented by, &c." *

* Essay on "Light," section 632.

Very small and *distant* are not terms for an exact science. From such data, what result can be found for philosophical deduction? What can be proved, what can θ and ϕ or χ be made to represent that has any approach to exactness?

Again: "In fact, the angle reckoned from the vertical, at which a tint, corresponding to a thickness T in the rings would be formed, is given by the equation $\sin. \rho = \frac{1}{\mu} \cdot \sqrt{1 - \left(\frac{T}{\mu}\right)^2} = \frac{3}{4} \cdot \sqrt{1 - \left(\frac{T}{\mu}\right)^2}$, taking $\mu = \frac{3}{2}$ for glass, which it is *very nearly*."*

I have made these extracts from Sir John Herschel, because he is the first authority, in order to show you, that, with as little the wish as I have the power to detract from his genius, or his accuracy, I am able to point out, that in his treatises on the most abstruse subjects, intended for the most profound study, he is unable to give to his demonstration that character of exactness which you claim for it.

DION. When we come to these minute and intangible variations, approximation can only be attained by these algebraic analyses.

ALASTOR. Yes; that is what I say, *approximation*. I do not mean to undervalue the method or the result; but I do mean to maintain, that approximation is not exactness. Nor does it—as my for-

*Essay on "Light," section 642.

mer quotation from "Herschel's Astronomy" proved to you—nor does this inaccuracy apply only, as you would say, to these minute and intangible variations, such as we have been examining in the "Essay on Light;" they are, as we have seen, as inexact, that is to say, the results are as mere approximations in the immensity of space, when applied to the theories of Astronomy.

DION. You cannot, in these vast combinations, deal with round numbers.

ALASTOR. *Round* being a term applied by you admirers of the exact science to the only true exactness which we can cling to—the sublime immutability of number.

DION. Sublime and immutable, and belonging to the essential nature of things, but unmanageably contracted in their powers. To advance a step in any science, you must have recourse to analysis.

ALASTOR. And what advance does that step make? It appears to me, that you step out of the sunshine into the darkness of night. Was it shown by this analysis that there really is precise and immutable harmony between it and observation, it would really be the supreme science which you assert that it is. **Here we have Astronomy and Analysis, and we find all they arrive at is *very nearly*.** We have found the same in the Theory of Light.

Then, in Chemistry; what can be more evanescent than its terms and its nomenclature?

DION. Do not call progress inaccuracy. New terms, new modes of expression, become continually necessary for each new accession of discovery.

ALASTOR. But each new term should represent something. Change is not advance; we can only advance by certainty.

DION. Certainty is a term hardly applicable where we are constantly moving onward. The certainty of to-day yields to the discovery of to-morrow.

ALASTOR. True. And where is the exactness of the science of chemistry? Advance is not necessarily change. Advance, if properly and philosophically used, should imply that one step is firmly fixed before we go on to another; if not, we retrograde, or go in a circle.

DION. Your progress would limit human invention miserably.

ALASTOR. On the contrary, I would free it from all shackles, and, by giving it a firm foundation, enable it to bound forward with force and certainty; and I contend that such firmness of foundation, such certainty of progress, has not been yet attained in the so-called exact sciences, because the term is misapplied. In his "Essay on Natural

Philosophy," Sir John Herschel says, "that the new inventions in the practical part of observation on mineralogy, have given it all the character of one of the exact sciences." How?

DION. By bringing it within the power of analysis.

ALASTOR. That is, we are enabled to *approximate* to some result beyond the power of numbers, and after proceeding through several pages of elegant (to use the approved expression)—of elegant demonstration, we come to the happy result of $= \mu^3$, or *nearly so*.

DION. You have done with analysis now, I suppose? I acknowledge, and no one ever denied, that it does not attempt to come down to the level of every understanding. It never pretends to arrive at the mere assertion that 2 and 2 make 4.

ALASTOR. Which homely truth is exact, because it is a part of our being; it partakes of the Divine, because we feel that it is unchangeable.

But, leaving analysis, what are the other sciences which claim this exclusive privilege of exactness, this right of private *entrée* into the Temple of Learning?

DION. That Dynamics and Geometry are exact sciences, I think, even you can hardly deny.

ALASTOR. Dynamics, or Mechanics! Nothing, as I said before, can be more vague than the terms

of this exact science, or more unfixed than its classification, more vague than the attempts to combine or to separate in the names which are given to its powers.

DION.. The names are, as I said before, nothing to the purpose ; they may be changed, but the power remains the same.

ALASTOR. So I say: the practical good, the advantage to the artisan the experience of ages has proved, and proves every hour: but that is to deprive it of the dignity of a science. You remove it at once from its niche in the temple, and you may amuse yourself with adapting to the figure new appellations, or with hanging about it new robes and ornaments ; but it is merely an idol, a senseless image. These names, screw, lever, and pulley, are, you say, of no consequence ; where, then, is the exactness of the science ?

DION. The results obtained have nothing to do with the particular words used to express the powers by which that result is obtained.

ALASTOR. Nothing in the world : only they are used in the authorities for these sciences, and changed by them, as I have said ; and however wise and just these changes may be, they destroy the character of exactness. The powers are immutable ; but there is in the would-be science nothing that can be called exact.

DION. All the results are capable of demonstration.

ALASTOR. By analysis? But you have given up analysis. You have acknowledged that it arrives only at approximation. You would demonstrate by Geometry, which you placed along with Dynamics, as one of the exact sciences. Take the first page of Euclid; it is a series of assertions which are to be granted before you can proceed.

DION. In rigorous fact, a point which is defined as occupying no space, takes up only what is an infinitely minute space; and——

ALASTOR. But, as I am really exact, I admit no such expression; infinitely minute is meaningless. You had better grant the assertion at once.

DION. It is indeed almost obsolete.

ALASTOR. Well, then, here is a treatise published a few years since; but, if you can, point out anything newer in this science, which is termed the most, the superlative of the exact. However, here we stumble at the very beginning. Parallel lines are still, it seems, undefined. Euclid and his followers assume, that if they approach, they must, if produced, meet——“which is the very point in question.” Here is an indeterminate in the very definition; and the doctrine of ratios is given up by the author’s candour. “Authors have invented a variety of ingenious devices to hide this transition;

but, however the defect may be concealed on a superficial view of the subject, it will always be found to be admitted or taken for granted.”*

Then we come to circles, and the measure of angles, where the author makes the same confession of attempted disguise;† and in the problem of the quadrature of the circle, “it is enough to know the ratio of the circumference to its radius or diameter. Hitherto the ratio has never been discovered, except *approximately*.” Would not it be honest, as well as more philosophical, to acknowledge that the quadrature of a circle is a problem that has never been solved?

DION. But perfect exactness is impossible to humanity.

ALASTOR. That is all I wanted you to allow; that was all I wished to prove; that was what we began with; you blamed Humboldt for not giving a theoretic rather than a speculative “Cosmos:” and I defended him by saying, that it was all humanity could do—that man looking at the world is still only man; and that as long as he observes, combines, and reasons upon what he can behold or comprehend, he is truly scientific—he is acting his real part: he is keeping his destined place: but the moment he steps out of it he loses himself. If he will usurp powers that are not his; if he will

* Note, p. 319.

† Note, p. 322.

presume to attempt to look at these things from a point of view which he can never reach, he falls, and perishes like all the Icaris of this vain endeavour.

DION. You would have no theory?

ALASTOR. There is no possibility of consistent reasoning without theory. Man must systematise, but he should systematise as man, and not attempt the ways of Providence. He must not argue upon intentions which he first invents, nor think that he is exalting the sense of deity by these childish mockeries of combination beyond his grasp. Perfect exactness is, as you say, impossible to man, and we should therefore drop such futile expressions, and instead of hampering and deceiving ourselves, we should acknowledge that we have not completed any science, that we cannot speak of what has gone before as utterly thrown aside, or what we have arrived at as certain. How many axioms have been rejected by one generation and put away by the next as obsolete, to be revived by the third as the truth. How little secure we can feel when now we hear of "this, our advanced state of scientific knowledge," that we have mastered one foundation stone. We reach in science, as in other kinds of cultivation and civilization, to a point from whence we again appear to retrograde, and we have not therefore any right to boast ourselves as now at an advance of knowledge never gained before; and it is one of the great

merits of Humboldt's "Cosmos" that he arrogates nothing.

DION. He tells you the discoveries of modern times as a forward movement in the march of mind.

ALASTOR. "Forward" is the watchword of human capacity—it is a part of our very being: it is this instinct for the beyond which hangs before the hero's eye—that "orb suspended" which leads him on so undismayed. It is this instinct, this indestructible consciousness of the yet unattained, which warms and lights us on the paths of every enterprise: that never-dying echo which still repeats this "Forward" even to expiring humanity, and makes at once the source and the security that there is a Beyond this world. Onward we must feel, or fancy, that we go—and as we go, we must believe that we have dropped along our road such wayside marks as shall be indestructible—tokens of our path which the birds of the air shall not devour, nor the sands of the desert overwhelm, nor the surges of invading oceans wash away.

DION. Such an indestructible landmark in the vast of human endeavours you consider to be Humboldt's "Cosmos?"

ALASTOR. Yes, a very bright, distinct, and unremovable Pharos. But it is bright and distinct because the eye is carried onward to it by all former bright and indestructible landmarks—he has not,

as he went along the way, knocked down and overturned each upright stone erected by preceding travellers; he has respected them, and pointed them out as those even unto this our day he has revered; he has often, with a pious hand, cleared, restored, and re-established these moss-grown piles, and urged the firm belief that in this dust prophetic we have the traces of past, or the germs of future science.

DION. It is his province: memory and combinations of memorials are the powers of Humboldt—not discovery.

ALASTOR. "Cosmos" was meant as a record of observation, not as a mere process of present invention.

DION. Invention is a higher power of the mind.

ALASTOR. The height depends upon the purpose.

DION. That which eventuates is more powerful than that which recollects.

ALASTOR. The Chandler who improves the making of farthing candles is an inventor, and Humboldt is his inferior, because he only tells what others have done.

DION. No, I would not be satisfied with your improved farthing candles! I must have a new kind of candle discovered.

ALASTOR. You go with the spirit of the age;

this kind of invention is the very boast of our generation.

DION. To conceive and to perfect the composition even of a farthing candle, or of a lucifer match, is a stretch of thought—the man who completed the first box of lucifer matches was (independent of the infinite use that he has been to the daily, hourly, comfort of mankind)—independent of its use, the mere invention marks him—greater than the inserter of the discovery in the past year's almanac.

ALASTOR. Especially if the inserter does as you do, and inserts as the first invention those now called Lucifers—inexact even in the science of Lucifers; they were originally Prometheans, and though Lucifers are an improvement, I claim for the Prometheans the priority.

III.

ALASTOR. It is well that we finished our debate upon exactness in the sunshine. We could not have kept up an argument in the soft stillness of the moonlight, with these deep shadows from trees that have so long remained beneath the "old and still enduring sky."

DION. On which we gaze and gaze, as countless men have gazed and gazed before, and never penetrated yet; even that broad moon, so silently looking at us, is it silently and senselessly too? Are there in her men speculating on what they see beyond their world, or is it a bare and barren emptiness?

ALASTOR. We have, as yet, perceived no traces of humanity on this our side of our satellite; but even the most resolute of our dogmatists has never maintained that there might not be inhabitants upon the antipodes, and perhaps some day they may creep over those volcanic rocks, and peep about at us; perhaps their Columbus is yet to discover their America, and in some few years Lord Rosse may point out to us the Washington, New York, and Boston upon this lunar America.

DION. A romance no one can refute, I suppose, and far removed from every suspicion of exactness.

ALASTOR. That mixed word of conjecture, speculation, and of deliberate research which constitutes, according to Humboldt, the happiness of a philosopher's existence, while "a presumptuous scepticism, which rejects facts without examination of their truth, is, in some respects, even more injurious than an unquestioning credulity."

DION. We cannot accuse ourselves of either; we have been this whole morning examining facts,

nor have we accepted even the highest authorities without questioning them. But, when Humboldt so much admires this "mixed mode" of conjecture and certainty, it is all the more self-denying and meritorious in him to avoid, as he does so resolutely, almost all attempts at conjectural emendation in the theories of the universe.

ALASTOR. Perhaps "Cosmos," which assumes only to be a view of what man has seen and done in the way of acquiring knowledge of this earth, and of all that he observes of other worlds; in such a work it would, perhaps, have been out of place to suggest new theories, or even to have attempted any modification of the old and established nomenclatures. But it is extraordinary that neither he nor any of the philosophers of our time should have endeavoured to simplify the system of the universe by getting rid of such anomalous terms as attraction of cohesion, and the centre of gravity. The idea of the earth being upheld by the force of magnetism is not new—it has been suggested and rejected; but why? Humboldt quotes, with applause, from Robert Gilbert.

DION. What a droll way he, or his translator, has of giving everybody almost their two names and dropping their titles, in the most Quakery fashion—we have not indeed Isaak Newton, he is allowed to be Newton; but it is always William

Herschel, James Ross, Robert Brown, and George Forster—a man whom Humboldt, with a pardonable nationality, places in a more exalted light than I ever saw him yet by any one else; and this George put to his name is amusing, as if we had a dozen “Forster’s Voyages Round the World,” and this particular voyager with Cook was George.

ALASTOR. Well: Robert Gilbert ridicules the notion of loadstones forming the poles. It may be absurd to suppose a great mass of rock at either end of the earth, as if they formed the centre of some vast pivots, on which the sphere was whirled; but why should not the Sun be a vast magnet, or mass of electro-magnetic matter, and the Earth, and all the revolving planets, electro-magnetic masses, attracted, suspended, and maintained in their courses by the same power? Why should we—contrary to the simplicity of Nature, and abhorrent to the wisdom of the philosopher—why should we have two powers to effect one purpose? Why should we persist in using the term attraction of gravitation?—a term which has no definite meaning—a vague, mysterious, undefined, and undefinable expression.

DION. Is Newton, too, to be accused of inexact expression?

ALASTOR. I accuse nobody: we need not go back upon that. My wish for exactness is from my

admiration for all the great discoverers, and for their discoveries; but it has been no detraction to Newton that succeeding astronomers have proved by improving upon his theories. Sir William Herschel's great telescope has not unhallowed the veneration with which we look at the plain little instrument with which Sir Isaak Newton made his observations. Herschel's great telescope lies now entombed: it may, in its material fabric, like its master, perish into dust; but the memory of him, and of it, and of the discoveries he effected, will never perish, or be effaced, or even dimmed. That greater discoveries may be achieved by the greater instrument of Lord Rosse will only enhance the glories of previous discoverers. Ørsted's "Researches in Electricity and Magnetism" have not degraded the discoveries of those who went before. On the contrary, we return with wonder and veneration to the lights which gleam upon us through the dim obscure of far-off ages. What I have wished to say all along has been that, what I feel to be unworthy of our men of science, is the trampling upon the past; the rejecting as forgotten lumber the painful labours of their predecessors; the presumptuous assertion of pre-eminent knowledge; the audacious assumption of *fixity of tenure*, for this our holding in the domains of knowledge. Newton placed the planetary system and the whole

extent of physical science in a form of beautiful simplicity, which must ever remain the glory of his age and his country. But it is no detraction to his merit to simplify it still more ; there is the power of magnetism, why should not we resolve these vague formulæ—Attraction of Gravitation and Attraction of Cohesion—into this single law of Magnetic Force?

“The weight of a body (considered as diminished by centrifugal force) is the effect of the Earth’s attraction on it. This attraction, as Newton has demonstrated, consists not in a tendency of all matters to any one particular centre, but in a disposition of every particle of matter in the universe to press towards, and, if not opposed, to approach to every other. The attraction of the earth, then, as a body placed on its surface, is not a simple but a complex force, resulting from the separate attractions of all its parts.” *

Attraction is here used indefinitely for attraction of gravitation, or gravity, and for attraction of cohesion—which are usually distinguished as the attraction which impels bodies to the earth, and that which coheres or maintains the integral parts of all substance, and this great globe itself, in one united mass. But why should we have these two separate kinds of attraction? “A disposition

* Herschel’s “Astronomy,” p. 127.

to press towards, and, if not opposed, to approach to," being an exact definition of magnetic attraction; the only difference now being, that the words which I have omitted in this sentence have not hitherto been supposed to apply to magnetism.

DION. You would then say that the masses constituting our own and the other planets, and the centre sun, are all sustained in their forms, and preserved in their courses, not by the two attractions of Cohesion and Gravitation, but by that which is called Magnetic. But if the whole earth is magnetic, in what does the power of the loadstone consist, or what is the force of magnetism, *per se*? Why, if the Earth's attraction is all magnetic, why should the near neighbourhood of iron deflect a magnetic needle; or why should a magnet attract and support any iron placed within its reach? How can this particular supersede the general law? How can the minute force of a three-inch bar induce another three-inch bar to overcome the universal force of the whole earth? And when this minute or particular exertion of magnetic force prevails over the great and general force, why does it act only on the whole of what it attracts as a whole—why do not the parts cease to cohere? Why, if this coherence depends upon magnetic attraction, should not in-coherence be induced by this particular force, which is, you say,

sufficient to withdraw the whole mass from that of the earth ?

ALASTOR. Why, if so-called Gravity pervades all matter—why should any one combination of matter have power to disturb this power ? Why should a hundred weight in one scale sink to the earth when there is but one pound in the other scale ?

DION. Because, according to Newton, all matter attracts all matter with a force directly proportioned to the MASS of attracting matter. The one hundred weight descends rather than the one pound, because the attraction to the earth, the force which induces it to move, is in proportion to its mass ; this attractive force, proportioned to the mass, being what is termed weight.

ALASTOR. The cause of the descent of the ounce is, you say, the force of the earth's attraction, but at the same time that the ounce descends the grain ascends ; why is the whole earth's attraction for the grain thus superseded by the particular attraction for the earth of the ounce ?

DION. Because such is the law of gravitation, or WEIGHT. The principle of weight is, that the attraction towards the earth increases *with the increase of mass*.

ALASTOR. What is there, then, different in our theories except names ? A magnet sustains a grain or an ounce of iron, it equally overcomes

the force of the whole earth's magnetic attraction in either case; as does your scale, with its ounce, overcome the gravity of the grain in the other scale. You call it weight; I call it magnetic attraction. Magnets of different sizes possess different degrees of attraction; that which would only support an ounce would not support a ton.

DION. But that which would support a ton would also support an ounce; and thus weight disappears.

ALASTOR. Put your grain and your ounce in the same scale and they descend together: exactly the same are the circumstances. The magnet sustains both ounce and grain—gravity causes both to descend to the earth.

DION. But if the whole attraction of the earth is magnetic, why should a single magnet exert its force only upon loadstone or iron?

ALASTOR. If force of gravity depends upon the mass attracted, why should the force of this attraction of gravitation be greater for an inch cube of lead than for an inch cube of cheese? Why is lead *heavier* than cheese?

DION (laughing.) Because it is. I really know no other reason.

ALASTOR. Then why should you require any other reason for the loadstone attracting iron rather than gold? Calling the force which sustains the world, or which combines the particles

of matter, by the single name of Magnetism, instead of the two names of Attraction of Gravitation, and Attraction of Cohesion, is only a simplification of nomenclature. It is no new system; it introduces no new power; it attempts no further insight into Nature; it withdraws not one fold of the veil that covers that mighty mystery.

DION. Specific gravity? What would you term it? How can you understand the inch cube of lead making its scale descend, while that of the inch cube of cheese ascends? Do you still say that lead is heavier than cheese? That the specific gravity of *plombine* is greater than the specific gravity of *lactine*, or how? What possible magnetic influence can there be between the magnetic mass of the earth and the cheese?

ALASTOR. I should still say, very simply, that the lead is heavier than the cheese, because, without any science, we are all aware of the fact—heavy and light are the words we use to express this result—the cause has been named specific gravity. “It is our own immediate consciousness of *effort* when we exert force to put matter in motion, or to oppose and neutralize force, which gives us this internal conviction of *power* and *causation*, so far as it refers to the material world, and compels us to believe that whenever we see material objects put in motion from a state of rest or deflected

from their rectilinear paths, and changed in their velocities, if already in motion, it is in consequence of an EFFORT *somehow* exerted though not accompanied by *our* consciousness." "All bodies with which we are acquainted, when raised into the air and quietly abandoned, descend to the earth's surface in lines perpendicular to it. They are, therefore, urged thereto by a force or effort, the direct or indirect result of a *consciousness* and a *will* existing *somewhere*, though beyond our power to trace, which force we term *gravity*."*

This is one of the latest definitions of gravity by our highest authority. Let us take this definition, that there is a power which influences matter, drawing it towards the earth, and this power is called Gravity. Let us, instead of this unknown power, or fictitious assumption of power, called Gravity—let us go to the known power, called Magnetism, or Electricity, "Magnetism is one of the manifold forms under which Electricity shows itself."†

Or, to take from a note in‡ "Cosmos" the expression of Knupho, a Chinese writer of the fourth century, "The magnet draws iron, as amber attracts the smallest grains of mustard-seed. It is as if a mysterious breath of air passed through

* Herschel's "Astronomy," p 232.

† Humboldt's "Cosmos," p. 176. ‡ Ibid. vol. i. p. lxi.

both, and communicated itself with the swiftness of an arrow."

"The earth's magnetism," says Herschel,* "is merely an effect of the continual circulation of great quantities of electricity round it"—the discovery of electro-magnetism having, as he says, shown that "a variety of causes, both geological and others, may be imagined, which may produce considerable deviations in the intensity, and partial ones in the direction, of such electric currents."

Instead of this vague supposition thus loosely expressed, of great quantities of electricity floating in space about the earth, "in a direction *generally* corresponding with that of its rotation," I conclude that the whole earth is magnetic, and that instead of adopting a term, such as gravity, we should use the word magnetism, which expresses a power with which we are acquainted. And, by extending this name by the addition of the word electro—Electro-Magnetism—we speak of a power whose effects are capable of experimental proof: we simplify all Cosmical phenomena, and avoid unphilosophical vagueness in physical science.

Specific Gravity may continue to be the term applied to express the abstract weight of bodies, although that gravity or weight is not, I say,

* Herschel's "Natural Philosophy," p. 328.

to be attributed to a SOMEWHAT hitherto-called Attraction of Gravitation, but to the magnetic power of the earth. What that power really is, we know no more than we did of the power we called Gravity; but we find in some forms of matter—as iron and amber—a force which attracts certain other masses of matter, or in which, in some cases, repels them. When we perceive this force, we should, although we cannot arrive at its source, any more than we can reach the source of animal life, or than we can comprehend the beginning or the aim of creation. Yet, perceiving this force, which we have agreed to call magnetism, we should endeavour to employ it as known, rather than lose ourselves in the application of an extraneous and inconsistent expression.

Let us, then, agree that “the reason why an apple falls,” may, without any disrespect to Newton, be termed magnetism, instead of gravity, and that though weight must be referred to “different intensities of that magnetism,” we can still call it weight, for, to our apprehension, all the phenomena of gravity remain the same, although we attribute these phenomena to a known instead of an unknown power—known, that is, so far that we can experiment upon, make use of, and direct its power. We shall then say that what we call difference of weight is caused by THE DIFFERENT

INTENSITIES OF MAGNETIC DEVELOPMENT. Here are several words which we must resort to for expressing a fact, though we have always still the consciousness that all these words bring us no nearer to the origin of these differences of intensity than did the former word gravity. But we have the mass of the globe—a mass of magnetic power: all matter above the surface of this globe is also a mass of magnetic power, and these masses, whatever be their shape, their size, their tensility, their compactness, or their situation, are attracted towards the superior magnetic mass of earth. Some forms of this matter are found more susceptible of this attraction than are others. In some, magnetism may be said to be more strongly developed than it is in others, so that smaller and more tangible masses are seen to attract each other, independently of the attractive force of the earth.

DION. So, a person in a state of clairvoyance may be said to be in a state of highly-developed magnetism! Some other mass of matter, some other person, has discovered their mutual susceptibility of attraction, and has, by a few visible and tangible operations of their hands, attained an experimental mastery over the other!

ALASTOR. Do not let us waste our time by spending a thought on that trumpery imposture, so absurd in itself and so clumsy in its execution,

that the veriest mountebank at a village fair would be ashamed of such performances.

DION. It simplifies the science of medicine, does it not? Is not it in accordance with your own theory? Does not it refer everything to magnetism?

ALASTOR. I do not refer everything to magnetism; nor are the tricks of empirics referable to any philosophical theory; nor does it simplify any science to attribute effects to contradictory causes. I do not want to make magnetism miraculous; that is to say, an action beyond, or inconsistent with the ordinary operations of nature, as we call those phenomena which are habitual to our own form and being, and to that of all created things which we can comprehend. I attribute no supernatural powers or effects to magnetism, or electromagnetism. I use it, as I find it. I substitute it for an unnecessary expression, and I think that with the closest reasoning, and on the most rigorous examination, we shall find my position hold good, and my substitution exact.

That the mass of the globe—this earth, affects a magnetic needle, has been observed for ages, and has been, and is being proved every day by new experiments, conducted with all the accuracy of modern invention; collected with all the zeal of the noblest searchers into science; combined and

reasoned on with all the supremacy of genius. All which might and majesty of man's endowments will, I am confident, agree in future to concentrate these, the results they have obtained, in the one simple form of expression, the magnetic attraction of the earth.

"The magnetic force of our planet is," says Humboldt, "manifested at its surface by three classes of phenomena; one of these is the varying *intensity* of the force, and the other two its varying direction shown in the *inclination* of the magnetic needle in the vertical plane, and in its *declination* from the geographical meridian. The aggregate effect may therefore be represented graphically by three systems of lines called isodynamic, isoclinal, and isogonic."* "The horary variations of the declination are apparently governed by the sun, whilst that body is above the horizon at any spot; they also decrease in angular value with the decrease of magnetic latitude near the equator. In the island of Rawak, for example, they barely amount to three or four minutes, while in Middle Europe they amount to thirteen or fourteen. Throughout the northern hemisphere, the movement of the north end of the needle from $8\frac{1}{2}$ A.M. to $1\frac{1}{2}$ P.M., or thereabouts, is from east to west; and as, at the same hours in the southern

* "Cosmos," vol. i. p. 170, 171.

hemisphere, the same end of the needle moves in the opposite direction, attention has been justly called to the presumption, that there must be a region of the earth," "in which no horary variation of the declination is sensible." "The perpetual fluctuation observed in all the magnetic phenomena, in the inclination, declination, and intensity of the force, according to the hours of the day, and even of the night, the season of the year, and the lapse of years, leads to the belief in the existence of very various and complicated systems of electric currents in the crust of the earth. Are these, as in Leebeck's experiments, simple thermomagnetic currents, the immediate effect of the unequal distribution of heat, or currents induced by the calorific action of the sun. Have the rotation of the earth and the velocity of its different zones, according to their distance from the equator, any influence on the distribution of magnetism? Is the source of magnetic action to be sought in the atmosphere, or in the interplanetary spaces, or in a polarity of the sun and moon?"

DION. It is extraordinary that Humboldt, in making these queries, did not himself suggest answers inventing your theory.

ALASTOR. It appears that the magnetic needle is subject to changes in its force, its angle, and in its level, and that these changes, having been noted,

are mapped in certain lines and figures over the globe. The variations from age to age are vague; but the careful observations of navigators and experimenters by sea and land, in latter years, has shown a certain regularity of curve in the lines laid down to delineate these changes, as if the cause of these variations might be, from this regularity, referred to some general and fixed rules. Or shall we* "regard so singular a configuration as the effect of local peculiarity in those parts of the earth"?

From the regularity with which these deviations follow one another so as to be laid down in the map in a form invariably oval, we might be satisfied that these variations increase and diminish according to some fixed power of attraction, which increases and decreases according to a fixed law; but then, the horary alterations are inconsistent with these gradual and great curves of variation; the law which governs the variations in space does not hold good in time. I should therefore say, that though "these phenomena, like all great natural facts, appertain to a general system and have a general cause," yet that they are in almost every case modified by "the effects of local peculiarity in 'different' parts of the earth."

* "Cosmos"—Terrestrial Magnetism.

Both the general law and the peculiar modification are proofs of the influence of a magnetic force to be found—not “in the atmosphere, or in the interplanetary spaces, or in a polarity of the sun and moon;” nor, as Galileo suggests, in “a centre of magnetic attraction existing in space;” but from magnetic attraction in the earth itself—a simple and sufficient cause for the general regularity—while it as simply and as sufficiently accounts for the peculiar modifications.

This simplicity of explanation has hitherto been puzzled and confused by the extraneous and unnecessary power introduced into our theories of the universe—that of gravity. Omit that, and have recourse to the one and sufficient power of magnetic attraction, and we rest at once on a certainty from which spring up endless forms of conjecture, inexhaustible happiness of observation and of experiment. We rest on the certainty of a power which we know, and on which we can experiment; though while we feel that in using the word magnetism instead of that of gravity, and thus simplifying our nomenclature, we still walk in a cloud of mystery: we advance no nearer to the source, the cause, the original of this power. But here it is—this power—and has been from the earliest recorded observations down to the present day—in the wildest of regions, on the shores of the Orinoko,

where the children, as Humboldt observed, had discovered and used in their play the attractive property of some leguminous seeds. There is this power observed and acknowledged in all space and all time of human duration ; and let us use it, and conclude from all the experiments made and mapped that the influence of the earth's mass upon the needle directs or draws it in one fixed direction, which we, in this hemisphere, call the North—this pole being *the centre of electric motion*.

DION. What do you mean by the centre of electric motion ?

ALASTOR. We need not go into that now, and in the middle of the night ; the moon has almost set, and we should set, too ; but let me finish my sentence. The influence of the earth's whole mass directs the needle northwise : the influence of local collections of magnetic force induces the variations observable in this northern direction ; and while we endeavour to form some general law for these variations, we must, with the minutest philosophy of experimental caution, take care that our inductions are from the general cause—the universal magnetic attraction of the earth—while we note as only individual modifications those facts which occur in our observations arising only from local accidents. When we know the variety of substances which may in a variety of circum-

stances produce electro-magnetism, we can only hope to reach any definite law for the actual deviation by constant, minute, painful, and incessant experimental observation, keeping in view always the one great principle that—ELECTRO-MAGNETIC ATTRACTION IS IN THE MASS OF THIS EARTH, NOT ONLY AS INDUCING PHENOMENA OF MAGNETIC ACTION, BUT AS CAUSING THE PHENOMENA OF THE DESCENT OF BODIES TO THE EARTH, WHICH HAVE HITHERTO BEEN ATTRIBUTED TO WHAT WAS CALLED GRAVITY.

IV.

DION. Another beautiful day—which I enjoy. I feel much more philosophically disposed in this bright sun than in a gloomy fog—much more Plato and Socrates like. So I begin Socratically with a question—What do you mean by the centre of electric motion?

ALASTOR. In CErsted's Electro-Magnetic Experiments, he, having charged his galvanic battery, and connected its poles by a conductor, or uniting wire, suspended a magnetic needle—so that the wire passed above and parallel to it—the needle moved, and the end of it next the negative side of the battery went westward, its inclination decreas-

ing as the wire was withdrawn to a greater distance from the needle; and, in pursuance of this first experimental proof of the identical nature of electricity and magnetism, Faraday suspended a horizontal piece of wire from the ceiling of a room, by a silken thread, dipped the two ends of the wire respectively in two basins of mercury, and then connected them with the poles of the battery, and the result was, as he had expected, a rotatory motion—a result which every succeeding experiment has confirmed and extended; the rotatory motion instantaneously ceasing on the disconnexion of the poles.

Such I suppose to be the immediate cause of the rotatory action of the planetary system. The ultimate cause, the original union of the connecting poles of that electric or galvanic action which maintains this rotativeness in the planets we cannot comprehend; but in its simplicity this theory seems worthy of the sublime order and precision of all that we observe of the Newtonian-Copernican system of the solar and planetary revolutions; the sun forming the centre at once of rotatory motion, and of sustaining attraction, while each planet, having its own centre, performs its own self-rotation; this centre in our earth being that pole towards which the magnetized needle is attracted, so as to point always towards it—while

our earth is itself to the moon the centre of its rotation, as Saturn and Jupiter are to their satellites. All these planets, and their revolving satellites, revolve, with their electro-magnetic force, round the centre sun.

DION. So you propose. Now let us compare your theory with the Newtonian or Gravitation theory. "On the one hand," says Herschel,* "*Gravity* is a real power, of whose agency we have daily experience. We know that it extends to the greatest accessible height, and far beyond; and we see no reason for drawing a line at any particular height, and there asserting that it must cease entirely; though we have analogies to lead us to suppose its energy may diminish rapidly as we ascend to great heights from the surface, such as that of the moon. On the other hand, we are sure the moon is urged towards the earth by *some* power which retains her in her orbit, and that the intensity of this power is such as would correspond to a diminished gravity 'in the proportion—otherwise not improbable—of the squares of the distances.' If gravity be *not* that power, there must exist some other."

ALASTOR. I say that gravity is not that power, and that it is some other, and that other electro-magnetism; and I deny that there is any such real power as gravity.

* "Treatise on Astronomy," p. 236.

DION. Herschel goes on to say, "Gravity must cease at some inferior level, or the nature of the moon must be different from that of ponderable matter; for if not, it would be urged by *both* powers, and therefore *too much* urged and forced inwards from her path."

ALASTOR. "Some inferior level,"—inferior to what? "urged by *both* powers." What are the two powers? Without, however, going into any of these inaccuracies, we may give up the whole theory; so exceedingly difficult to reconcile with its own laws, and which involves so many contradictions. The sun, to be capable of attracting the earth, is made to* "contain 354,936 times the mass or quantity of ponderable matter that the earth consists of. Nor let this conclusion startle us. We have only to recal what has been already shown (article 305) of the gigantic dimensions of this magnificent body, to perceive that in assigning to it so vast a mass, we are not outstepping a reasonable proportion. In fact, when we come to compare its *mass* to its *bulk*, we find its density to be less than that of the earth."

How are these assertions reconcileable? the sun attracts the earth by being 354,936 times "the mass or quantity of *ponderable* matter that the earth consists of." And yet we are told, imme-

* "Treatise on Astronomy," p. 239.

diately after, that the sun is composed of *lighter* material though greater in bulk than is the earth. Again, we are told that the earth and the moon, preserving their own revolutions in their own orbits, circulate round the sun, the sun sufficing to keep this earth and her satellite in their annual journey round the sun without separating them: but at the same time we are told also that,* “if the moon simply revolved about the earth under the influence of its gravity,” “its orbit would be a perfect ellipse returning into itself, and always lying on one and the same plane: that it is *not* so is a proof that some cause disturbs it and interferes with the earth’s attraction, and this cause is no other than the sun’s attraction—or rather, that part of it which is not *equally* exerted on the earth.”

Can this attraction, which attracts the *whole* system of the moon and the sun, also give a *part* of this attraction to a *part* of the system? Without any of these difficulties or contradictions, my theory of electro-magnetic rotatory motion explains the sustenance of this our system—that is, the relation between the earth and the moon, as revolving each round its own centre of electro-magnetism, while the moon at the same time revolves round the earth by the same electro-magnetism, and both together perform a gyration round the solar electro-magnetic

* “Theory of Astronomy,” p. 241.

centre : the sun performing its own rotation on its own electro-magnetic centre at the same time. From the independence of these movements we avoid the contradictory nature of gravity, which is supposed to sustain at the same time that it attracts to divergency. The attraction of gravitation on the surface of the earth is supposed to induce all matter towards itself; the extent of this attraction is, as Herschel tells us, beyond our highest mountains and further : but this very attraction is supposed to be what perpetuates the course of the moon in her orbit round the earth. Once projected, it is stated, her course is thus sustained by the exactly regulated relation of her mass, and the attraction of gravitation in the mass of the earth. These contradictions—the tendency to come to the earth's surface, and its power of only upholding without withdrawing—are at once destroyed by the theory that motion of the moon is independent of the earth's attraction. The magnetic affinity of matter towards the earth, which occasions the disposition of all matter to descend towards the earth's surface, is a power in the earth, and concerning only the phenomena observable on the earth and its atmosphere—and has nothing to do with the performance of her own rotation or revolution, or with those of the moon. "The* moon's orbit is not, strictly

* Herschel's "Treatise on Astronomy," pp. 227, 228.

speaking, an ellipse, by reason of the variation of the plane in which it lies and the motion of its nodes." "The best way to form a distinct conception of the moon's motion is to regard it as describing an ellipse about the earth in the focus: and at the same time to regard this ellipse itself to be in a two-fold state of revolution; 1st, in its own plane by a continual advance of its axis in that plane; and 2ndly, by a continual *tilting* motion of the plane itself."

From these words we should suppose that there was an actual material road—a race-course, on which the moon *does* it in 29 days, 12 hours, and 44 minutes: but as this is not the case, we can explain the phenomena of the moon's apsides without any confusion of terms, or the introduction of the imaginary orbit as a material path. The electro-magnetic—

DION. You need not say electro-magnetic. It has been proved by Ørsted and Faraday, &c. &c. that the formerly so-called magnetism, is produced by and identical with electricity; but as the electric attractive power is most familiar to us under the name of magnetic, let us agree to understand by magnetic—the power of attraction caused by electric or galvanic action.

ALASTOR. The rotatory motion of the moon round its own magnetic centre is not, we discover

by observation, perpendicular to her orbit, so that we are enabled to perceive, by her libration, that she has this rotation. This her own self-rotatory, and her earthly and her solar gyrations, account for the imperfect elliptical shape of her course, and for the motion of her nodes. As the earth is also in constant motion, both self-rotatory and gyratory, round the sun, and the sun itself also self-rotatory, their several relations, or the shape of their courses in space, must vary constantly, and are observable to us on this earth, and the amount of these variations calculable in numbers.

The other planets already discovered I consider as in like manner gyrating round a magnetic centre. "The apparent* motions of the planets are much more irregular than those of the sun or moon." "We find," however, "universally, that the interval of time elapsing between the successive passages of each planet through the same node (whether it be the ascending or descending) is always alike, whether the planet, at the moment of such passage, be direct or retrograde, swift or slow, in its apparent movement. Here, then, we have a circumstance which, while it shows that the motions of the planets are, in fact, subject to certain laws and fixed periods, may lead us very naturally to suspect that the apparent irregularities and com-

* Herschel's "Treatise on Astronomy," pp. 244—6.

plexities of their movements may be owing to our not seeing them from their natural centre, and from our mixing up with their own proper motions—movements of a parallactic kind, due to our own change of place, in virtue of the orbital motion of the earth about the sun."

Not only "very naturally" may we be led to this inference, but we must philosophically lay it down as a necessary fact—inseparable from our situation on the earth—inseparable from our position on a body constantly rotatory, and constantly gyrating—that is, always revolving on its own magnetic centre, and always travelling round the magnetic centre or sun of its system. These motions necessarily interfere so much with our views, direct or telescopic, of all the other bodies of the universe we behold, that we should not speak of the planets as really "advancing rapidly," or "relaxing in their speed," or as "reversing their motion, and moving back upon their former course." The word "apparent," which is introduced as the epithet only to speed in the sentence I have just read, "relaxing their *apparent* speed,"—this word apparent should properly be applied to the whole description of the planetary motions, as our description is necessarily only of the motions apparent to us—apparent at such vast distances; and these appearances modified by such a variety of combined

and relative and irrelative movements of our own earth, that we should content ourselves with only attempting to state what we actually observe, and theorizing only on the general principle that bodies whose apparent movements are the same as those which we have ascertained with regard to the earth and the moon, that these movements are carried on by the same power, and according to the same laws—we conclude that the planets, which we have by observation ascertained to travel round the centre sun—we conclude that they perform this journey by the same magnetic influence that our own planet, the earth, does, and that they possess the same self-rotatory and solar-gyrating power as does our earth and its moon, and we are confirmed in our trusting to this analogical conclusion by our observations of the moons or satellites of Jupiter—observations the most complete and satisfactory which science can effect.

Now, in the attraction of gravitation theory, all these movements of the different bodies in our system are perplexed by the necessity of allowing for the perturbing influences of neighbouring bodies. Sir John Herschel,* after some laboured analytical investigations of the phenomena exhibited by two attracting bodies, says, "Yet on descending to a more rigorous nicety, and especially

* Essay on "Physical Astronomy," part ii. section 1.

on comparing together observations embracing a very long series of years, it is found that the result of the calculations founded on the assumption of elliptic motion according to the laws above demonstrated, do not represent the observations perfectly. In a word, though the elliptic theory agrees very nearly with observations, yet, to make it tally rigorously with them, it is necessary to introduce modifications." And then he proceeds to state, how much increased are the mathematical difficulties, when we come to ascertain these modifications, with regard to a great number of revolving bodies, and the whole solar system. In the case of two bodies, he says, "there we had no difficulty in integrating the differential equations of the problem. Here, on the other hand, the equations are too complicated to allow of their integrals being exhibited otherwise than in series: and even then we have no means of ascertaining their laws. Fortunately, however, this is not necessary: the enormous preponderance of the sun's mass in our system being such, that the fractions representing those of each of the other planets are enough to allow of their squares and products being neglected without any fear of inducing appreciable errors. It is a well-known theorem, which extends the application of mathematical reasoning to natural phenomena, that, when several causes of motion

act together, if their effects taken singly are of such an order of minuteness that their squares and products may be disregarded, then their joint effect will be the sum of the effects which would be produced by each acting alone. This principle allows us to regard the disturbance or perturbation of any one planet, produced by the joint action of all the others, as the sum of the effects each would produce separately: so that we may simplify the investigation by leaving out of consideration all but a single disturbing planet, and applying the analytic formulæ so investigated to each in succession, we shall thus obtain expressions for the perturbations produced by each, which, added together, give the total perturbation."

We are, in the electric rotatory theory, "fortunately for us," enabled to do without all these omissions, and "coaxings," and errors compensating errors. In this theory, the revolving force of solar electricity is alone sufficient to maintain the motion of the planet in its own orbit: each planet, in its own mass, is considered to have its own magnetic force, attracting within the sphere of its own surface, but extending no further: thereby avoiding not only these perturbations which have so perplexed astronomers with a fear of change, which they would endeavour to account for, unmindful of the monstrous anomaly of the

sun's attraction being sufficient to keep Saturn in his distant orbit, while it is not enough to pull Mercury, who is in such near neighbourhood, out of his!

DION. It is curious that, in speaking of the gradual diminution of attraction of gravitation towards any body by the increase of distance, Herschel* makes use of these words:—"The gradual enfeebling of attraction towards any body by an increase of distance is not only a natural supposition, but is borne out by the strong analogy of magnetic and electric attractions."

ALASTOR. In my theory, the analogy becomes the fact. The lessening of magnetic attraction by distance annihilates the danger of perturbing attractions from neighbouring planetary masses; while it suffices, from the whole earth's mass being, according to the theory, magnetically attractive, it suffices to bring down to its surface all THAT CAN RISE FROM THAT SURFACE TO ANY HEIGHT ABOVE IT.

The precession and natation of the earth's axis is, in the magnetically rotatory theory, no longer a vague and perplexed confusion between the actual pole or point of the earth and the imaginary lines described by it in space; but this change in the place of the pole of the earth is the actual movement inseparable from its magnetic rotation on its

* Essay on "Physical Astronomy," part 1. section 1.

own centre. The rotation of the earth round its own centre of magnetism is invariable, as is its gyration round the solar centre; and what is called the Precession of the Equinoxes will be found to be rather an error in the imaginary ecliptic than a real alteration in the time or course of gyration, constituting the apparent annual revolution, or in the moment which astronomers have agreed to call the sun's arrival at the equinox; but many of their difficulties, and much of the perplexity in which they involve themselves and their scholars, arise from the habit of speaking of ecliptics, poles, zones, and equators as actual material realities—a childish error, which has led to serious misapprehensions.

In all that I have hitherto said, I have not intended to overturn, or even to shake any former system; least of all have I meant to attack the Newtonian. I have only substituted a known for an unknown power; I have only withdrawn from the simplicity of Newton's theory those complexities which must arise from the attraction of gravitation; I have separated the earth's magnetic force, exerted on bodies within reach of that force, from the compelling power by which its diurnal and annual revolutions are sustained; and while electricity has hitherto been considered as vaguely floating in currents round our globe, I consider

the globe—our earth, as itself a mass of electro-magnetic force, on the phenomena of whose power science may exult in endless inquiry. I have, to use the noble expressions of Sir John Herschel,* endeavoured “to raise our hopes of the future progress of science, by pointing out the simplest and most obvious combinations as those which are actually found to be most agreeable to the harmony of creation, and to hold the cheering prospect of difficulties diminishing as we advance, instead of thickening around us in increasing complexity.”

In all systems of physical science, with regard to the motions of the earth and the other planets, some original CAUSE is granted. In the Newtonian theory, the planets are considered to be set in motion by an inscrutable power. In every Cosmos, whether we are taught that our solar system is but the fragments of a former world left by some concussion in space, or whether we are told that it was created at once as it is, there must still have been a creative power. By the Newtonian theory, the earth, which we inhabit, and all the other planets, are endued by this original creation with the attraction of gravitation, by which, having been once set in motion, they are sustained in their courses. For attraction of gravitation, I substi-

* Herschel's "Natural Philosophy," p. 306.

tute that of magnetism, and assert that, whether the planets and the sun are fragmentary of former worlds, or created at once as they are, the Creative power has endued all the planets of our universe with that force at once so subtle, and so stupendous, which we call magnetism, or electricity. By this, from the central sun, which is a mass of electric agency in constant action, emanates that electric operation on the magnetic masses of the planets which, at their creation, was begun, and is maintained, and must so continue to be maintained, as long as the electric agency of the sun's mass continues in activity. While each individual planet, on its own magnetic axis, and subject to its own internal completed circle of electric influence, continues to rotate on this its own peculiar centre, while still vivified and maintained by the solar magnetic centre, these revolve round some other lesser planets or satellites.

There we behold those distant worlds in the repose of their eternal motion; the sun, the first adored of human superstition, and those "five other wandering fires" the fabled deities of poetic mythology—and the latest found of modern science—there they revolve in viewless orbits, on those unseen centres which the original creative force endued with that combination of magnetic influences whose mysterious depths are still to us so

incomprehensible: the more mysterious, as we are so far in possession of its secrets. In miniature we can produce by the electrical machine the dancing of the pith balls in an electrified atmosphere: the mimic representation of the planetary gyrations. We can make a galvanic battery, and we can connect the ring of circulating force: we can see it pulsating in the voltaic pile, or through the palpitating spiral, or whirling the ball, the magnet, or the needle. Or we can suspend or drop enormous weights at a touch, as we connect or disconnect our magnetic wires; or we can speak in an instant of time along a magnetic line of hundreds or thousands of miles in extent. But what this power which we call magnetism is, we know no more than did Thales in the earliest ages of our world. We do, however, know its effects, and we can produce them: we may therefore reason on those effects produced upon the grand scale of the universe. We consider the sun as the centre—a mass of magnetic matter evolving its own light and heat, and having attached to it at the centre the ends of the connecting ring of that productive force which is always at work in this centre sun, and which by this electro-magnetary influence, causes and maintains the revolutions round it of the planetary world. Suspended, moved and maintained to this magnetic or electric centre, once electrified and

repelled into their present positions, the eternal action of the electro-magnetic centre so maintains the planets ; while their own internal magnetic activity—the ends of that internal connecting and conductory ring of circulating galvanism being united from the beginning, and to continue united as long as they are to continue their rotations—these, so moved by a process independent of and unconnected with that of their solar gyrations : a process subsisting in the interior of each planet mass : they have revolved, and continue to revolve in their several orbits and on their several axes, undisturbing and undisturbed.

DION. But could any mass of electrical force, even that of such a body as the sun, suffice to maintain in constant action the distant planets, such as Saturn and Herschel?

ALASTOR. When a little galvanic battery can send a message along a wire from London to Dover, we need not hesitate about the electric force of the sun being sufficient to maintain as distant, or more distant planets. The maintaining powers of electro-magnetic force being free and unrestrained, we are not embarrassed in our considerations of its action by the perplexities of gravity. We do not know what electricity is—but we do know that its force can occasion a distant, or a near body, to revolve. All the bodies within the

sphere of its action revolve; but it has not a tendency to attract the nearer rather than the distant: and here we avoid one of the most startling anomalies of the theory of gravitation, viz., why it should have power to sustain the distant, and not have power to withdraw the near bodies from their orbits.

V.

Dron. Your theory is ingenious, but till it is subjected to the most rigorous analysis I shall not put implicit faith in it.

ALASTOR. As soon as analysis is really what it is called, "an EXACT science"—when analysis arrives at honest results, and is not satisfied with approximations gained by the omission of so many squares and square roots, and all the tricks through which the calculator works, its test will be worth trying; but when we saw, in what I read to you yesterday from Sir John Herschel's "Physical Astronomy," in what a wretched state the science is, when a man of his first-rate genius, one of the first mathematicians of the age, a man of the highest honour, and of the most ardent devotion to philosophic truth, yet, when doing—as we may suppose he did on such a subject—when doing his

best at it—what inapt conclusions do we find throughout the whole essay!

DION. Humboldt does not agree with your depreciation of this science, for he says,* “It is no small testimony to the value of analysis, *sometimes so contemptuously regarded* in the unscientific circles of civil life, that by his complete theory of tides Laplace has enabled us to predict, in our astronomical ephemerides, the height of spring tides at the periods of new and full moon.”

ALASTOR. Has he? Let us now consider what is said by one of the first authorities† on the completeness of Laplace’s tidal theory.

“In remarking on these methods, we cannot fail to observe that Mr. Lubbock’s method of using *all* the observations for his first results, and the methods founded on this by Mr. Whewell, are, in some respects, greatly superior to Laplace’s, which used only observations made at particular times. Thus, Laplace *assumed* that the principal corrections for parallax *must* occur on the days when parallax was greatest. Mr. Lubbock’s method, if properly used, would show whether that is true or not.” “Laplace gave very little attention to the times of the tides, and, moreover, in the discussion of solstitial and equinoctial observations, he con-

* “Essay on Tides and Waves,” in “Encyclopedia Metropolitana.”

† Ibid.

fined himself to the times bordering very closely on solstices and equinoxes on both sides of them, and therefore the increase of the square of declination could not appear." And again, in calculating the effect of parallax on the height of the tide at Brest, the observed difference was 47.27, and that deduced by Laplace theoretically was 51.52—this theoretical difference arising from Laplace's choosing to use only the declination, instead of declination and parallax. Again, "The equilibrium theory and Laplace's lead us to expect that the diurnal tide will be large in middle latitudes, and small near the equator and near the poles." "The fact of observation is, that the diurnal tide is as large near the equator as in middle latitudes." "The value of Laplace's theory is lost in a great measure, because the solutions hitherto attempted apply only to those cases in which $i = n$ exactly or $i = 2n$ exactly." "Laplace's theory would be much more valuable, if it were extended so far as to include the effects of friction." "Laplace's theory of the movements of the sea, supposing the globe to be completely covered by water, whose depth is uniform, or follows a very simple geographical law, has far too little regard to the actual state of the earth to serve for the explanation of the principal phenomena of tides." The diurnal tides, too, in the

Pacific, are in total contradiction to Laplace's theory of no diurnal tides. So that, so far from his analysis bearing out a *complete* theory for the tides, his fundamental positions are incompatible with observed facts, and his solutions inconsistent with both theory and practice.

DION. But why should you attack Laplace in particular, when your magnetic theory must destroy the whole idea that

Pressed by the moon, mute arbitress of tides,

they are dependent on her, or modified by the sun?

ALASTOR. I did not mean to attack Laplace, nor would it be possible to demolish the estimation in which so great a man is justly held. But I wished to show you that even Humboldt could be mistaken, and that Laplace's analysis of tides was an unfortunate instance for the accuracy of the science.

As to the "mute arbitress," she is, of course, dethroned by my theory. The tides are not, according to the magnetic system, caused by the Moon's attraction; and by getting rid of her influence and that of the Sun, we get rid of the great stumbling-block of the tide being equally affected at the further and the near side of the Earth to the Moon, the explanation of which is thus given by

Herschel: *—"The tides are a subject on which many persons find a strange difficulty of conception. That the Moon, by her attraction, should heap up the waters of the ocean under her, seems to most persons very natural; that the same cause should at the same time heap them up on the opposite side, seems to many palpably absurd. Yet nothing is more true, or indeed more evident, when we consider that it is not by her *whole* attraction, but by the differences of her attractions at the two surfaces and at the centre, that the waters are raised. A drop of water existing alone would take a spherical form, by reason of the attraction of its parts; and if the same drop were to fall freely in a vacuum, under the influence of a *uniform* gravity, since every part would be equally accelerated, the particles would retain their relative positions, and the spherical form be unchanged. But, suppose it to fall under the influence of an attraction acting on each of its particles independently, and increasing in intensity at every step of the descent; then the parts nearer the centre of attraction would be attracted more than the central, and the central than the more remote, and the whole would be drawn out in the direction of the motion in an oblong form; the tendency to separation being, however, counteracted by the attraction of

* "Treatise on Astronomy," p. 335.

the particles on each other, and a form of equilibrium being thus established. Now, in fact, the Earth *is* constantly falling to the Moon, being continually drawn by it out of its path; the nearer parts more, and the remoter less so than the central; and thus, at every instant, the Moon's attraction acts to force down the water at the sides at right angles to her direction, and raise it at the two ends of the diameter pointing towards her. Geometry corroborates this view of the subject, and demonstrates that the form of equilibrium assumed by a layer of water covering a sphere under the influence of the Moon's attraction would be an oblong ellipsoid, having the semi-axis directed towards the Moon longer by about fifty-eight inches than that transverse to it. There is never time, however, for this spheroid to be fully formed; before the waters can take their level, the Moon has advanced in her orbit both diurnal and monthly (for in this theory it will answer the purpose of clearness better if we suppose the Earth's diurnal motion transferred—the Sun and Moon in a contrary direction); the vertex of the spheroid has shifted on the Earth's surface, and the ocean has to seek a new bearing. The effect is to produce an immensely broad and excessively flat wave (not a circulating *current*), which follows, or endeavours to follow, the apparent motions of the moon, and

must, in fact, if the principle of forced vibrations be true, imitate by equal, though not by *synchronous* periods, all the periodical inequalities of that motion. When the higher and lower parts of this wave strike our coasts, they experience what we call high and low water. The sun also produces precisely such a wave, whose vertex tends to follow the apparent motion of the sun in the heavens, and also to imitate its periodic inequalities. This solar wave co-exists with the lunar—is sometimes superposed on it, sometimes transverse to it, so as to partly neutralize it, according to the monthly synodical configuration of the two luminaries. This alternate mutual reinforcement and destruction of the solar and lunar tides cause what are called the spring and neap tides, the former being their sum—the latter their difference. Although the real amount of either tide is, at present, hardly within reach of exact calculation, yet their proportion at any one place is probably not very remote from that of the ellipticities which would belong to their respective spheroids, could an equilibrium be attained." I have given you this long passage of explanation, because I suppose it is the best that is to be had. And now, are you much the wiser? Does all this give any reason *why the tides should be affected equally by the moon at both sides of the earth*, which was to be done?

DION. No; I do not think it does. It has one great fault in any reasoning, but especially in what is meant for reasoning at once popular and scientific—I mean that of a false supposition for the sake of explanation. In this theory, he says it will make it clearer to transfer the Earth's motion to the sun and moon. I do not see how it clears up any thing, and, besides being false, it is puzzling.

ALASTOR. Moreover, you will observe that, in the end, he says, no exact result has yet been obtained for the real amount of either tide; only we *might*, if an equilibrium *could be* attained, find that the proportions of these tides at any one place is *probably* not *very remote* from the ellipticities which would belong to their respective spheroids.

DION. Which is all “highly satisfactory.” But does the “Essay on Tides and Waves” you were quoting from throw no light on this subject?

ALASTOR. No, none. The author candidly acknowledges that all the observation and calculation of France and England have failed to establish a theory.* “Throughout the whole of this subject, the selection of the proper theoretical ground of explanation is a matter of judgment. In some cases, we may conceive that we are justified in using the equilibrium theory; in others, the wave

* “Essay on Tides and Waves,” section ii., article 14.

theory will apply completely or partially. In a few cases, the results of observation in one locality will be considered as a fundamental set of experiments, upon which the explanation of the phenomena in other localities will be grounded without further reduction to theory, and as a last resource, in almost every case we shall be driven to the same arbitrary suppositions which Laplace introduced."

Now these local phenomena are, according to the magnetic theory, of more consequence than they have hitherto been regarded. In all former theories, the tides are spoken of as in a great body of unbroken ocean—as if the Moon's attraction, and that of the Sun, were acting on, and drawing towards them an external coating of water, which lay unbroken over the earth. But such not being really the case, we should consider the tides as they appear in different localities, and presenting different phenomena. No author that I have seen offers any explanation of the tideless nature of the Mediterranean that is at all satisfactory. The tide is scarcely observable, all authorities agree, in that sea; while at Venice it is, though small, sufficient to be perceived, and at Annapolis, in the Bay of Fundy, the tide rises, says Sir John Herschel,* 120 feet. And he accounts for this fact, by the tide-wave rushing up a narrow channel, which

* "Theory of Astronomy," p. 339.

suddenly raises it to an extraordinary height. Why should that rush affect the tide at Annapolis, and not at the Straits of Gibraltar, where the whole swell of the Atlantic only makes itself slightly perceptible at the *entrance* to the Mediterranean, and not at all on the Syrian coast, while that in the Adriatic is nothing near the entrance, but very plainly marked at the Venetian end? Because, says the writer on "Tides and Waves," a tide, insensible at the mouth, becomes sensible at the head. It does so for the Adriatic, but not for the Mediterranean.

But all this has nothing to do with the Moon or the Sun; if their influence depend on their position with regard to the earth and to each other, the influence must be constant, or, if modified by circumstances, those modifying circumstances should always be consistent. We see that they are not so.

DION. The ephemerides and almanacs, their calculations for the tides,—what do you do with them?

ALASTOR. What do they amount to? They are said to be calculated from the moon's changes, because the "influence of the moon on the tides has been observed from the earliest ages." The times of the tide's ebb and flow vary from day to day, and so does the figure or appearance of the moon's form to our eyes; but there is the whole of the con-

nexion. The moon has as much to do with the tides as she has with the weather. The ease with which traditional authority is given is not surprising among the unlearned. It is singular that the most profound in science should as easily take upon trust the unproved assertions of ignorance—"the moon enters her first quarter"—as if she walked into an inn at the end of her first stage. We see a little more of her light to-day than we did yesterday, and what possible effect can that have on the clouds which clear and leave an open sky above our earth, or which descend upon it in snow, rain, or hail? The increase and decrease of light from the moon, as we look at her, is regular and certain; the changes in the weather irregular and uncertain to that degree, that no looking forward can fix upon what it may be. The moon is said to be "at the full" on a certain day, and as she is to affect the tides, they should be at their height then; but though said to be dependent, the movement of the moon and of the tides "are not synchronous."

The Sun, too, does not perform his part correctly either, as his "efficacy fluctuates between the extremes of 19 and 21."

And extraordinary high tides: how accounted for by the Moon? Let us look at the tide at Bristol: here are the data—the difference between the

Moon and the tide at Bristol, 40—at London, 52. The tide on the Irish coast is nothing, while between Wicklow and Wexford; very strong all along the east coast to Wicklow. Why does the Moon affect one part of the same coast, and not the other?

Leaving out the Sun and the Moon, then, as they possess no influence on our globe—what causes the sea to advance upon the shore at one hour, and then to withdraw itself some hours afterwards? Why does not the ocean rise beyond the boundaries of island and continental shores? What prevents its incursion at Brighton? Why should not it overflow the coast from Brighton to Mount Edgecumbe? Or why should not the Atlantic have long since submerged the whole of Africa? Is not there water enough in that vast ocean? If the waters of the Atlantic and the Pacific were moved only by the winds, and showed no other alteration in the level mass which it exhibits in repose than that of waves and billows, we should only say that the ocean was made to keep its place, and the land its place; and we should look upon the Pacific as upon a great tub filled with water to its brim, and which could only overflow by outward agency; but when we see the waters of this ocean advancing and throwing themselves on the land—surging onward and upward on the shore—what is to stop it? Where is it going? Will it submerge the Earth?

While we gaze, the waves splash, recede, and again advance, leaving at each successive splash a further mark upon the shore. Now, as we gaze, we doubt whether they continue to advance before they recede, or whether they cease altogether to advance. We perceive that they only recede; and so they continue to do till they are again altogether withdrawn from the shore, and leaving it uncovered and bare before our eyes, we wonder where these surging waves have all withdrawn themselves away to.

DION. Much more marvellous is the tide in an inland sea, as I have seen it in the Scotch lakes—the gradual creeping on of the water inch by inch, gaining slowly and surely on the shore—no fluctuation, no splash; it moves onward with a resistless quietude, whose very repose is sublime. One feels in the visible presence of a Supreme Power. I doubt if the most furious tempest, sweeping away forests and toppling down rocks, would impress me more with inscrutable force than the soft ripple of that slow advancing tide.

ALASTOR. The coast tide, which ebbs and flows, and falls in waves, and the unebbing gradual advance of lake tides, alike arise from the magnetism of the earth contending with the magnetism of the sea. The variations in the hours, and the force arising from the local accidents of different coasts and different seas, must always remain subject to

local observation and allowance—as at present, when the law is supposed to be ascribed to the influence of the moon and of the sun, and whence the tables are formed: even with these tables, local allowance is made for London, Liverpool, and Bristol, &c. All Whewell and Lubbock's elaborate calculations are formed from a mass of observations, so that at last the result of their mathematical deductions could be only speculative—could relate only to a general theory; for as far as practical use, the repeated and collected observations from a variety of places must, in each of those places, effect all practical and local purposes. For practical ends, then, experiment and recorded observation have been, and must always be, the basis; and as, according to my argument, the theory has hitherto been mistaken, it cannot, for daily use, make any difference, our attributing the tides to the attraction, magnetic, of the land and of the water; but as to scientific inquiry into truth, it is a philosophical improvement.

Observation has pointed out a great wave of tidal flow extending along the Atlantic; and analysis has endeavoured to calculate the rules of its motion. I conceive this motion arises from the magnetic attraction of the American continent endeavouring to draw the waters to its shores; resisted by the magnetic attraction of the main

earth beneath the waters, while the waters are themselves kept in tension and unbroken by their own magnetic attraction of particle to particle; and this struggle of the opposing magnetic influences endures—that of the American continent conquering—till, from the rotation of the earth, the waters begin, as Herschel expresses it, to fall off, and the wave, retreating, falls towards the continent of Africa, whose magnetic influence begins with the water the same struggle, the same drawing towards the land, and withdrawing by the under-sea influence, which always, at last, prevails. The absence or feebleness of the tide in different places is consistent with this theory, because the motive influence is direct; it is from the land itself, and must therefore vary from the nature of that land. These variations in the degree of tide, which, in the theory of the causal influence being the sun and moon, unvarying in their general relation to the sea and to the land, occasioned an invincible anomaly in all former tidal theories, which the profoundest mathematician and men of the highest genius have struggled in vain to overcome, as long as they endeavoured to do so by the impracticable laws of gravity—these difficulties have only been increased by the voluminous registries of local observation. The endeavour to reconcile the variations thus recorded has involved the

calculators in an inextricable mass of difficulties in their attempts to generalize the rules for tidal periods. Such attempts have never attained any practical result; in all the tables of the tides they are made out, "for London," or "for Dublin," corrected by observation; and even these corrected tables are frequently set at nought by "extraordinary high tides," which occur without any error of the moon in coming nearer to the earth than she was wont, without any conjunction with the sun, or any of the modes by which an influx of gravity could be accounted for—they are literally "extraordinary high tides;" and where they cannot be accounted for by mere meteorological phenomena, of heavy rain or swelling rivers augmenting the volume of the sea upon the coasts, where they fall into it, these extraordinary tides are referable to an AGGRAVATED INTENSITY OF MAGNETISM in the mass of the earth—the whole earth being magnetic, and its central interior being, as I have said, a constantly active reservoir of electro-magnetic agency, with a recurring power of regeneration in itself; this recurrence depending as it does not only upon the constant electric action, but upon the varying nature of the materials attracted from the earth's mass, and absorbed into the electric reservoir, and acted upon and reproduced, such varieties of formation result in what to human

observation appear to be fitful influences, throughout the globe's whole mass to its surface; and thus by its increased—and only occasionally increased—(occasionally, as the magnetic agency swells up and subsides) power—draws in an occasionally increased or extraordinary high tide.

Local causes, though allowed for in the moon theory, are, as I have said, so loosely detailed as to be absurd, which discrepancies I said enough about just now; and we may now set at rest all these discrepancies and all the complicated uncertainties of tidal calculations, by referring the general ebb and flow to the magnetic influence of the Earth upon the Sea, and the particular exceptions to particular and local varieties in the magnetic structure of those particular localities.

DION. Fine subjects for experimental proof.

ALASTOR. Experiment may, perhaps, in every instance confirm my theory; but the presence of magnetic force in particular localities may arise from such interior and deep-seated causes, or from such slight varieties in different soils, as to elude the nicest experimental research.

Barometrical observations, too, have often confounded the experimenter, when proceeding on the laws of gravity and the pressure of the atmosphere—the rise of the mercury in a barometer in fine weather being attributed to the increased

pressure on the mercury in the cup or fountain, arising from the increased *weight* of the atmosphere; a theory which is supposed to be confirmed by the fall of the mercury on ascending a mountain where the pressure of the atmosphere is diminished. These practical results, though not agreeing with practical sensations, are supposed to be of practical utility; but the theory is, as far as meteorological observation goes, irreconcilable with human feelings. The "barometer falls," we say, for bad, and "rises" for good, weather. Our feelings are that, on a wet foggy day or in the close and heated stillness, the precursor of a thunder storm, the air is so oppressive that our breathing is less easy—that the whole atmosphere is *heavy*. Yet, it is precisely at these times that the mercury falls; which fall we are told is because there is then a less pressure on the mercury—that the air is then *lighter*. This contradiction must, proceeding on the laws of gravity and pressure of the atmosphere, be conceded as inexplicable; but the contradiction is avoided and the difficulty solved if we refer these changes of height, this rise and fall in the barometer to its proper cause—the increase or diminution, or rather the altered distribution, of electro-magnetic influences which belong to the meteorological changes. Humboldt, in enumerating the causes which affect

barometrical phenomena gives, “ *The electric tension of the atmosphere*, of which the primary source, when the sky is serene, is still much contested ;” and may ever continue to be so contested, because the changes in the weather, and in the electricity of the atmosphere, are so sudden, and so minute, and so local, that although the most popular and most interesting form of practical science, as affecting all agricultural processes and the health and comfort of mankind, yet, from the rude observation of “silly shepherds” to the recondite researches of Humboldt, from all the collected observations and experiments of all ages, no certain law by which the expected weather can be predicted, has yet been arrived at. The barometer is sometimes a guide, but often a very uncertain one to the atmospheric changes, because its fall is occasioned by the descent of electric agency, as the air thickens and becomes impregnated with electro-magnetic matter, the result of the ever-acting mutability in the relation of atmospheric particles—as the superimpending air above any locality of the earth becomes thus impregnated, its tendency is, from the electric affinity or magnetic force of the earth, to descend towards it. In doing so, it alters the relation between the fountain of mercury and that which is in the tube ; it causes a depression in the fountain by its attractive influence drawing the mercury

in it towards the earth's magnetic mass, and so lowering that in the tube as it sinks into the fountain to fill the depression ; and on the dispersion of this descending electro-magnetism the tension on the mercury is withdrawn, and it again remounts in the tube. The inaccuracy or subtilty of these changes, which prevents this rise and fall from being an accurate predictive gauge, arises from that constant mutability of electric action which is essential to our atmosphere, and also to all the accidents of peculiar situations.

In barometrical measurements of heights this subtilty of motion, and these local accidents, make it, at least in the present state of experimental science, a very inefficient method of measurement. Boiling-water, though apparently a ruder, is, in fact, a more accurate process, for it really depends on the pressure of the atmosphere ; but in the barometer the fall of the mercury and difference between its height at the top from what it was at the bottom of a mountain, or of a high building, do not depend on the superincumbent atmosphere, but upon magnetic attraction. The massing together any quantity of terrestrial substance produces a more or less increase of magnetic attraction, which increases as by ascending the height the greater mass of attraction is left below ; so that at the depression of the mercury in a baro-

meter at the top of a church steeple, its fall from the height it showed at the bottom, arises from the direct drawing downwards of the mercury by the increased magnetic mass to whose influence it is subject, and if ascertained by repeated experiments would give a tolerably accurate result. But in the ascent of a lofty mountain, the mercury is subject to attraction and depression, lapsing and increasing, to rise or fall at every step, from electromagnetic influence of clouds and meteorologic changes, and from variations in the local sites of magnetic substance in the nature of the rocks, the strata, and all the differences of geological varieties, besides the actual direct attraction of the mountain mass ; so that, when at the top, the height of the mercury in the tube, or its difference from what it was at the bottom of the mountain, is no criterion of that mountain's height ; for though, from the increased rarity of the atmosphere, it would be probable that the mercury would be higher than at the bottom of the mountain, it is usually found to be lower, because though to the feelings the air is light because it is exhausted in its lower strata of its depressing magnetism ; and in the same way the mercury in the barometer is high in the plains on a clear frosty day, although we find ourselves and all about us in a highly electrical state ; because, instead of being collected

in an attracting mass, drawing the mercury downward, the electricity is dispersed through the air and cleared of its magnetic downward tendencies.

THE TIDES, THEN, ARE CAUSED BY THE MAGNETIC ATTRACTION OF THE SHORES TOWARDS WHICH THE WAVES ARE DRAWN; THE FLOW UPON ONE SHORE LEAVING THE EBB UPON ANOTHER—AND THE TURN, OR CESSATION, OF THE FLOW OCCURRING WHEN THE MAGNETIC FORCE OF THE EARTH'S MASS BENEATH THE OCEAN, OR THAT OF AN OPPOSITE CONTINENT OR SHORE, OVERCOMES THE MAGNETIC ATTRACTION OF THAT LAND WHICH IS DRAWING TOWARDS IT THE MASS OF THE SEA IN A TIDE.

THE RISE AND FALL OF THE BAROMETER ARE CAUSED BY AUGMENTED MAGNETISM OF EARTH'S ATMOSPHERE, WHICH, INDUCING THE DESCENT OF THIS ATMOSPHERE IN ITS ATTRACTION TOWARDS THE MAGNETIC MASS OF THE EARTH, THIS DESCENDING ATMOSPHERE DRAWS DOWN WITH IT THE MERCURY IN THE BAROMETER—AS DOES THE MAGNETIC MASS OF A MOUNTAIN WHEN A BAROMETER IS CARRIED TO THE TOP, AND ITS HEIGHT THERE COMPARED TO WHAT IT WAS AT THE BOTTOM,—IT SHOWS NOT THE DECREASED PRESSURE OF THE ATMOSPHERE, BUT THE INCREASED MAGNETISM OF THE MOUNTAIN.

VI.

DION. How beautiful are Humboldt's allusions to his personal acquaintance with the countries of which he speaks—the very slightness of them gives a truth and verisimilitude to what he says.

ALASTOR. Yes ; they have the sort of charm which the same kind of individuality gives to Sir Walter Raleigh's "History of the World," where, in the midst of a dry relation taken from the dim chronicles of the past, and all about the grey shadowy forms of antiquity, we have suddenly the present living form of the writer, now, as to us, as dim and grey as those he wrote about ; but how personal, individual, and real does it sound—as if he spoke to us :—"I have produced these authorities in part to justify mine own relation of these Amazons, because that which was delivered me for truth by an ancient Cacique of Guiana—how, upon the river Papamena (since the Spanish discoveries called Amazons), that these women still live and govern." How vividly he brings himself, in his morion and corslet, speaking to the ancient Cacique in his chaplet of feathers, and how instantly it brings us back, with a single word, to the possibility of a time before South America and the Amazons were familiar as Syria or the Euphrates—to the time

when the New World was still new, and when men doubted whether there was such a world; and when tales of men whose heads beneath their shoulders grew had to be gravely refuted. And, again, how all the chivalry of France starts up before us when he says—as “I saw in the third civil war of France.”* Katherine of Medicis and the haughty house of Guise, and all the “thousand heavy times” of those long contentions, seem real, when the man who speaks to you says he saw the third civil war of France.

DION. There is a sort of differential parallel between these two great men, Raleigh and Humboldt:—their genius, their far-off travels, the difference of the age and country to which they belong; while each has attempted a “Cosmos;” Sir Walter’s unfinished historic collection of events—Von Humboldt’s completed circle of scientific knowledge; the romantic minds of each—each breaking forth unexpected in the dry details of wars or of inventions.

DION. How beautiful is this passage in “Cosmos,” when speaking of *ærolites*, *asteroids*, and *meteoric phenomena*:—Our intercourse† with all other cosmical bodies, with all Nature beyond the limits of our own atmosphere, is exclusively either

* Raleigh’s “History of the World,” folio, pp. 164, 165.

† Humboldt’s “Cosmos,” vol. i. page 126.

through the medium of light, and of radiant heat intimately united with light, or through the mysterious force of attraction exerted by remote bodies, according to the measure of their distance and their mass, on our globe, its ocean, and its atmosphere. But if in shooting stars and meteoric stones we recognise planetary asteroids, we are enabled, by their fall, to enter into a wholly different and more properly material relationship with cosmical objects. Here we no longer consider bodies acting upon us exclusively from a distance, by exciting undulatory vibrations of light or heat, or by causing, or themselves undergoing, motion by the influence of gravitation; but we have actually present the material particles themselves, which have come to us from the regions of space—have descended through our atmosphere, and remain upon the earth. A meteoric stone affords us the only possible contact with a substance foreign to our planet. Accustomed to know nontelluric bodies solely by measurement, by calculation, and by the inferences of our reason, it is with a kind of astonishment that we touch, weigh, and analyze a substance appertaining to the world without; the imagination is stimulated, and the intellect aroused and animated, by a spectacle, in which the uncultivated mind sees only a train of fading sparks in the clear sky, and apprehends in

the black stone which falls from the thundering cloud, only the rude product of some wild force of Nature."

ALASTOR. Beautiful and romantic, but not philosophically or accurately reasoned. Humboldt tells us that his theory of *aërolites* is, that they are dropped upon our earth from some of the meteoric streams, "consisting of myriads of small cosmical bodies which intersect the orbit of the earth." They are, he says, all of an unmistakable character, though very various in the proportions of their combined materials. These materials, being all of the nature of the materials of our own planet, should not be, he says, any reason why they should not belong to another planet, or to other masses of matter moving in space; none of these exhibit "any flattening from the effect of the fall"*—by which sentence he shows that he thinks it possible a body might fall from these unpenetrated regions of space,† and come in contact with the earth, without "any *flattening* from the effects of the fall." Could they come with "the enormous planetary velocity of meteoric stones,"‡ and, meeting the surface of our earth, escape being shattered to pieces? Even a cannon-ball, projected from and returning to the earth, buries itself in the ground. How, then,

* "Cosmos," p. 26. † Des profondeurs de l'espace. LA PLACE.

‡ "Cosmos," p. 26, note.

could these masses of metallic matter fall with "enormous velocity," and settle quietly on the plains of Siberia, or the banks of the Orinoco? Falling from the profound of space, with the accelerated velocity of their descent, and meeting the solid mass of this earth in their progress, there they stop, receive no injury, and make no impression on the ground where they fall, although he tells us they did, at sundry times, kill some monks: that is to say, a body of "seven feet in length"* (he does not tell us the thickness or weight), falling from regions beyond the earth, had the force of a pistol bullet half an inch in diameter—which will do as much for a monk, or any other man, at twenty paces distant. Humboldt argues against the possibility of these meteoric stones proceeding from volcanoes in the moon, but without perceiving the impossibility of any such masses of matter arriving upon this earth, without being either shattered to pieces by the contact, or being buried in the depths of the ground. He says, in speaking of the calculations on this theory of their lunar origin,—“This Calistic problem† occupied for ten or twelve years the attention of the geometers, Laplace, Biot, Brandes, and Poisson. The then prevailing, but since abandoned opinion, of the existence of active volcanoes in the moon,

* "Cosmos," p. 109.

† Ibid. p. 25, note.

where air and water are absent, caused the public to confound two things extremely different, viz., a mathematical possibility and a physical probability."*

Can that be physically improbable which is mathematically possible? Is not it making the one science false? It is, in fact, acknowledging the futility of mathematical demonstration, or analytic systems, in proof of physical operations. Here are given by Humboldt the different rates at which the supposed erupted masses from the moon were projected towards the earth; but the impossibility of such masses falling at this rate, without being, at their concussion with the earth, shivered to atoms, or buried beyond all human ken, seems not to have occurred to him.

Humboldt truly observes, ("Cosmos," i. p. 122,) that "even in the field of what must necessarily be conjecture, its course must not be arbitrary, or irrespective of conjecture." And as, justly, he reasons that the other planets may be composed like the Earth, why should not the polar regions of Mars be splendid domes of ice and snow? and why should not Mars, Mercury, or Venus, or the Sun, be surrounded by floating or revolving masses, mineral combinations of crystals of olivine or labradorite, or of nickel and of iron? There is no proof either that there are, or that there are not, these

* "Cosmos," note p. 25.

floating masses of mineral aggregates: but if, as Humboldt argues, there are these floating masses, they are, according to the theory of gravity, supported in space by the attraction of gravitation—this attraction being sufficient to maintain the whole mass, but not sufficient to prevent a small portion of it from being withdrawn by the sudden superseding attraction towards the Earth. Whence this sudden descent? But these falling masses may not, according to Humboldt, be now—immediately preceding their fall—detached from a larger mass; they may be, in these small portions, whirling along in the train of other small or large mineral conglomerations, when the force of retaining gravity is suddenly, and for them only, interrupted, and down they come.

DION. This theory is obviously irreconcilable with that of gravity.

ALASTOR. Yet Humboldt quotes from the Greek philosophers their system, of these falling meteoric stones being falling celestial bodies, which are detached in consequence of an interruption in the general rotatory motion: he quotes this as more nearly allied than any other theory to that which he maintains. But this theory of the Greek philosophers, though consistent for them, is incompatible with that of gravitation. For in the attraction of gravitation we always come to the same diffi-

culty—why should the same power retain in, and attract from, an orbit? Why should this sustaining power, by which, according to the theory, the whole universe subsists in its course—why should it be interrupted, for a little lump of nickel and iron to come to our earth, without a general interruption of the whole system? Or, if one of these portions strike against another, and is knocked out of its place, what occasions this concussion? How do these supported bodies become thus hurried in their course—or, if always hurrying, how have they been prevented from dashing each other to pieces, or from falling in inextricable confusion among all the other heavenly bodies?

DION. In fact, Humboldt gives no distinct theory, accounting for these so-called meteoric stones reaching this earth. I have looked in vain through the text and the notes of these eloquent passages in "Cosmos," but there is no definite law or theory about them.

ALASTOR. He considers as improbable ("Cosmos," i. note, p. xxvii.) the theory of these *aërolites* being the result of certain gases, as Fusinieri supposed, which held in solution these metallic substances in the upper strata of the air, "and which suddenly aggregate from a state of extreme dispersion." This is a vague statement. What is *extreme* dispersion? And what causes sudden aggregation? But though

inconclusively and vaguely expressed, this gaseous theory is less contradictory than that of interrupted gravitation; and by keeping their origin in our own atmosphere, it avoids the insuperable difficulties of "the enormous planetary velocity of meteoric stones," ("Cosmos," i. p. xxvi. note) suddenly descending on earth, unshattered, and unburied in earth's surface, and the confusion of contradictory gravities, and the unaccountableness of suddenly-interrupted universal laws of revolution. Fusinieri's theory avoids these, but goes unnecessarily to chemical, instead of electric combinations. According to the electric theory, there is no need to go to distant worlds, or to bring from other planets these *aërolites*, or to compose them, by vague processes of unaccountable combination, from the indefinite chemistry of gases.

DION. You do not, however, deny the existence of these metallic masses called *aërolites*?

ALASTOR. No one could attempt to deny, what all may see—blocks, or pieces of iron, or nickel, with an "adust" outside, which exhibits traces of the action of fire, and which are, though with varieties, all of the same composition—some of which have been known to be of recent appearance, and some of which belong to the earliest traditions of our world. Some are discovered in the longest-civilized and most cultivated portions of the globe—some in

the wildest and most inaccessible regions: they have been in all times the subject of wondering conjecture; they have been attributed to the anger or to the favour of deities, and swords and images and altars have been formed of them, and trusted to and worshipped as of divine power and of divine original. They are composed of nickel and iron, cobalt, manganese, chrome, copper, arsenic, tin, potash, soda, sulphur, phosphorus, and carbon, and olivine and augite crystals. What are these substances? They are found in the substance of our planet, the earth; but what is their composition or their origin? "All the planets, and all the spheroidal masses which revolve around the sun, we may permit ourselves to surmise," says Humboldt ("Cosmos," i. p. 122), "have been formed by the gradual condensation of gaseous matter, separated from the once more extended solar atmosphere." Why he should be satisfied to refer the origin of the whole planetary system to "gaseous matter," and object to allow it to be the origin of *aërolites*, does not appear. But I reject both hypotheses. Gaseous matter is a vague term, and the sudden combination of this gaseous matter is equally vague, while electric results are in their nature sudden; and as our atmosphere is, to demonstration, electric in its very essence, it is making unnecessary difficulties

to go to any other source for these aërolites. They are composed of nickel and of iron. What, I repeat, are these substances? Are not they themselves the result of electro-magnetic origin? What caused the atmosphere to be electric is beyond our conception; what originated the ever-recurring changes of our atmosphere, and of all our meteorological phenomena, we know not; but we do know that we have these phenomena, and from the KNOWN we derive securely, especially as these aërolites are generally, by tradition and by contemporaneous observation, referred to the appearance of a thunder-storm with lightning, or the descent of what is called a fire-ball. Humboldt carefully notes popular and legendary tales on meteorological phenomena, as traces, at least, that such phenomena have been; and the common expression of the "fall of a thunderbolt," or the classical legend of "the image that fell down from Jupiter," alike refer these meteoric stones to electric agency. Nickel and iron are found in what we call the earth: that is, substances which we name metals are found along with other substances which we name earths: these metals have been formed, I argue, by electric agency, and what we now call aërolites are thus formed—not falling from volcanoes in the moon, nor dropped in the concussion of other planets, nor falling out of an imaginary

ring of fiery gaseous matter—which are supposed to be sustained in their course by an agency which is suspended without cause, and removed without injury to this supposed sustained course—not belonging to any other world, but the result of those electric changes in our own atmosphere, which belong to our own observation of our own planet. That such metals are actually formed in the air by electric combinations seems most probable, from the mass of evidence which speaks of these *aërolites* as falling *on* the earth. But it would be more consistent with other facts, and more consonant to other processes of nature, to suppose that these masses of nickel, and iron, and olivine, were the result of the contact of electro-magnetism with the earthy or other substances of the globe. How, or why, these streams or darts of electricity descend to the surface of the globe is, as yet, incomprehensible; but in the contact of one of these flashes or balls of electric light and heat, I consider that an instantaneous galvanic or electro-magnetic action takes place, and the instantaneous transformation of clay into metal is effected. The mines, or strata, or particles of iron or nickel, discovered below the crust or surface of our globe, I refer to a similar and previous interior agency; but we now consider only the outward atmospheric effect of electricity—that the mere action of this electricity in the air,

in the atmosphere which surrounds us, and which appears to be of so rarefied and *unmaterial* a consistency, seems difficult to be reconciled to our knowledge of combination.

DION. But with your electric theory, I should have thought that Humboldt's gyrating masses of gaseous matter would have exactly agreed. I should have thought that you would have struck off from them, by electricity, the meteoric stones, and so avoided the difficulty of what you quoted just now of sudden chemical action.

ALASTOR. I do not adopt these floating gasometers, because I do not understand what is meant by them. And chemistry being one of the EXACT sciences, I do not find it stated anywhere by Humboldt himself, or by any of the authorities which he quotes, whether in chemical they include electric or galvanic action? Nor, in my acquaintance with gases, am I aware of their containing matter—earthy or metallic materials—that would combine by chemical or electric power into the bodies which we call *aërolites*. And even if I allowed that these *aërolites* were producible and produced in these gaseous revolvers—they revolve, according to Humboldt, round the sun in space, and at that distance from which their descent would be subject to the same unconquerable difficulties, whether produced by electric or by chemical action,

or by the *accidental* falling away of particles or masses : that is, according to the theory of gravitation, the sudden and unaccounted-for interruption of the sustaining force, to permit the fall of one body towards the earth, while all the other parts of this gaseous body remain suspended by their attraction to the sun.

DION. That would be merely changing the word chemical for electric. I mean, that you should adopt the gasometer into your own electro-magnetic theory of gyration, and make the fall of the *aërolites* strictly meteoric, the result of the constantly-working electric action—reconciling too, thereby, your theory with Humboldt's, of the production of the heavenly bodies from this gaseous mass, and allowing it to be, as he does, the scattered remains of what has been heretofore aggregated into what we now behold as heavenly bodies.

ALASTOR. In that case you must cease to use the word gaseous ; or we must agree that, by gaseous, we are to mean earthy-metallic, or, according to the cosmical phraseology, TELLURIC matter. It is, in fact, only moving the creative power one step—it is saying, that space was filled with floating gaseous telluric matter, and that—attraction of gravitation, slowly condensing, or electro-magnetic action suddenly combining—this space-suspended telluric gas became the planetary system, leaving the dross,

which gravitates, or magnetically rotates across the earth's orbit round the sun. This is—either according to the attraction of gravity, or, as you would reconcile it, with electro-magnetism—the theory which Humboldt supposes for the past and present of the universe, and from which he deduces his explanation of the *aërolites*.

DION. Of the *aërolites*, and so-called falling stars.

ALASTOR. Let us deal only with *aërolites* at present; and let us understand by gaseous or vapoury masses—or “*nebulae*” “in different stages of development,” “more or less condensed towards their centres”—telluric matter, which “is becoming, or about to be,” “a new condition of matter.” (“*Cosmos*,” i. p. 75.) And from this suspended telluric mass Humboldt supposes the *aërolites* descend; and you would reconcile the electro-magnetic theory with his, by supposing that these *aërolites* are separated, condensed, and projected to earth, by electric action. But this does not account for the appearance of these meteoric stones: there is still the insurmountable difficulty of these masses, whatever is their magnitude, meeting the surface of this globe unshattered or unburied. Humboldt gives, as evidence to be relied upon, that in the course of all the centuries through which we hear of these meteoric masses being on earth—that during that time, only four can be found to have injured human

beings; "although, according to Schrideus, it is probable that 700 falls of aërolites now take place each year." ("Cosmos," i. p. 31.) In all this time, and this quantity, only one friar in 1511, and one monk in 1650, and two sailors in 1674, have been killed. But we are not told what became of the meteoric stones in either case; and in that of the "two Swedish sailors on board a ship" we should have been informed what became of this murderous stone—did it knock them on the head and rebound into the sea? were there two stones—one for each sailor—or were both killed by the same? and did it, or did the two stones, having descended through space with their "enormous planetary velocity," only kill two sailors—settle quietly on the deck of the vessel, without, as might have been expected, crashing right through deck and all, and destroying the vessel, in its course? I have drawn out this tradition or record *ad absurdum*, only to show the vague uncertainty of such evidence; and as the theory of the FALL of aërolites depends on such evidence, I put it away altogether, and going from the fact, which all may see—and which is incontestable and distinct—that there are found, in various parts of this globe, masses of nickel, iron, and olivine, &c., which masses are not part of the earth, but are discovered on its surface. They have been supposed to come from the moon:

this theory has been abandoned, and we need not go over it: I have shown the impossibility of such masses descending on our earth undestroyed or unburied, and I refer them to the action of electricity on the earth itself: I refer them to the descent, not of a mass of metallic matter, but of electricity in action—a flash, as we call it, of lightning, or a fire-ball, or a thunderbolt—the combination of our ever-changing atmosphere in sudden electric force, descending on a spot upon the surface of the globe, and, uniting with the earthy matter it there encounters, forming the mass which we call *aërolites*, or meteoric stones. The air, or atmosphere, which is between us and what we call the sky, or blue vault of heaven—this atmosphere is always changing—now cloudy, now clear; now condensed in falling rain, now congealed in hail or snow; now filling, as it were, all space with palpable obscure, in mist or fog, now bursting forth in hurricanes, the viewless sublimity of wind, or in all the audible and visible majesty of thunder and lightning—

Sunt tempestates et fulmina clara canenda—

are the very conditions of what we name the elements. One of these electric phenomena, the descent of lightning on some combination of earthy matter—clay or rock, or whatever we may term it—forces this matter at once into a new combina-

tion ; and the iron or the nickel which we find in the interior of the globe have been thus formed by the former action of electric combination.

DION. Why should not these metals have been created at once as they are, as well as the matter from which they are, as you say, made into their present state ?

ALASTOR. Because we find these *aërolites*, or formations of nickel, olivine, iron, &c., as recent formations on the surface of our world. I therefore consider all these as composites, by electric action on previously-existing matter. If, according to the floating gaseous theory, a mass of iron or nickel was formed in the air of what is understood by gas—that is, without the presence of any solid material—and if by chemical or galvanic action the solid matter of these meteoric stones was formed, it would not be combination—it would be PRODUCTION. Between a flash of lightning acting upon gas in the air, or descending upon and acting on earthymatter, there seems but a little difference ; but it is all the difference between what we can comprehend—that is, combination of matter resulting into different compositions—and that which is incomprehensible, the creation of actual matter ; the difference between “ a new condition of matter already existing,” and “ the act of creation itself the original calling forth of existence out of non-

existence, of which we have no experience, nor can we form a conception of it." ("Cosmos," i. p. 75.)

Even if there was in our atmosphere gaseous solution of material particles, which, by electric combination, resolved into meteoric masses of metal or crystal, I have proved that they could not have touched our planet undestroyed; and I therefore conclude that AËROLITES, OR METEORIC STONES, ARE FORMED ON THE SURFACE OF OUR PLANET, BY THE ACTION OF ELECTRICITY IN OUR ATMOSPHERE, IN THE FORM OF WHAT WE CALL LIGHTNING OR FIREBALLS, DESCENDING UPON AND COMBINING WITH EARTHY MATTER, CLAY, OR ROCK, AND RESULTING IN THESE MASSES TERMED AËROLITES, which have hitherto been supposed to have reached our planet as they are now found, but which have always been, by universal tradition and philosophic speculation, attributed to meteoric and electric phenomena: I only change the *locus* of their formation.

VII.

DION. It is inconsistent, as you say, of Humboldt, to attribute the origin of the planets to gaseous combinations, and deny it to aërolites; nor do I see why he should consider as so very improbable Ampère's hypothesis, of the earth's heat resulting

from the long-continued chemical action of earths and alkalies on an oxydised external crust.

ALASTOR. Ampère's own words are—"On ne peut douter qu'il existe dans l'intérieur du globe des courants électro-magnétique, et que ces courants sont les causes de la chaleur qui lui est propre"—("Théorie des Phénomènes Electro-dynamique," p. 99)—words which I quote with satisfaction, as supporting my own electro-magnetic-dynamic theory of the universe, and especially that of earthquakes and volcanic eruptions. Humboldt's supposition of the more recent cooling of the earth, and the whole system of the Vulcanists, of an interrestrial region of fire, is subject to many difficulties which the electric theory removes. I consider the interior of the earth, and that of the sun and all the planets, to be of the nature of what we call a Galvanic battery. The success that has attended all the experiments tried by this powerful agency has put us in possession of a degree of acquaintance with an agency in the phenomena of the universe, which should simplify and sublime all our conceptions of its past and present workings. The original touch of life—the creative—is inscrutable; we can only reason upon what we see or hear, or have had reported, and we can only refer these phenomena to agencies which we can comprehend.

Earthquakes are the most remarkable of the

phenomena with which we are acquainted. They are not merely reported or recorded—they record themselves; they are not only placed among the remarkable events in all the chronicles of Roman history, but written in unmistakable characters on the very globe itself: the fairest cities, towns, and temples—the pride of man's supremest art—lie buried in a moment, and Nature's noblest and most steadfast-seeming works, the mightiest mountains, are riven asunder, or laid even with the plain. These sudden and stupendous occurrences are referred by Humboldt, and many other theorists, to a nucleus of fire in the interior of the earth, which he connects with electro-magnetic currents, but only connects; he does not refer to electro-magnetism as the actual cause of these events. "If, on the one hand, the internal heat of our planet may be connected with the excitement of electro-magnetic currents, and the evolution of terrestrial light accompanying a magnetic storm, it is also a principal source of geological phenomena." ("Cosmos," i. p. 189.)

"It shows the relations which subsist between the ejection of various substances, on the one hand, and earthquakes and elevations on the other. It classes together groups of phenomena, which appear at the first glance very heterogeneous, as thermal springs, exhalations of carbonic acid gas

and sulphureous vapour, harmless eruptions of mud, and the devastating phenomena of active volcanoes."—p. 190.

DION. I do not know why he should speak of all these phenomena as heterogeneous ; they seem all very naturally resulting from one cause.

ALASTOR. Yes, and that an internal and constant electro-magnetic action ; an action which, while maintaining by its magnetic chords the rotation of the whole earth, and causing the descent and stability of all bodies towards and on its surface, is constantly internally at work ; and as its electric force increases, it bursts the earthy crust above it, and by this safety-valve, as Humboldt calls it, lets off the constantly-forming and superfluous electric matter. Earthquakes, which result from the efforts of this internal electric action, are only ineffectual volcanoes. In an earthquake, the electric action, instead of running directly upwards through the solid materials above it, takes a lateral direction, and, meeting resistance which its force is not at the time equal to overcome, it results in the movement of the superincumbent mass, which ends, according to the force of the electric agency, in a rift of the surface, or an upheavement of masses, or displacing of strata and overthrow of cities, and the wreck of nature's fairest forms ; while, in volcanoes, the electric action is more

powerful—it is upward-lightning, resulting from the inward terrestrial, instead of the outward atmospheric electric action, and instead of descending upon, it bursts through the surface of our world, fusing, melting, burning through all that it meets in this its upward course, and pouring forth, as it finally emerges, all that it has driven before it, which appears upon the surface as lava, mud, or boiling springs, or innocuous vapour, as the electric action is more or less violent, or according to the materials it has encountered in its passage; while the continuance of these effects of lava-streams, or boiling geisers, depends also on the material upon which the electric action has to work, or the depth below the surface where its action commences: “On ne peut douter,” says Ampère, (“Théorie des Phénomènes Electro-dynamiques,” p. 99,) “qu’il existe dans l’intérieur du globe des *courants* electro-magnétiques, et que ces *courants* sont les causes de la chaleur qui lui est propre.” The word currents, I change to INTERIOR AND CONSTANT ACTION.

DION. Why should you refer all the internal warmth of our planet, and all its volcanic effects, to electric action only? Why should not there be also internal fire? As Humboldt says, “the ceaseless action of electro-magnetism *and* subterranean heat,” (“Cosmos,” i. p. 153), why should not both be

referred to as the causes of past and present geological or cosmical phenomena?

ALASTOR. I consider the heat, the constant heat, of the earth to be, as Ampère does, the result of electro-magnetic action; and not only the regular warmth which we discover as far as we have been able to penetrate, but as also the cause of the flames and streams of volcanoes. The presence of a continual fire in the centre of the earth is liable to the invincible difficulty of want of material to feed upon—the impossibility of the supply being equal to the demand. Fire on the surface of the earth burns only as long as it has air and material to consume; it cannot, then, exist where there is, by the terms of the proposition, no air, and where, by the very nature of what we call fire, it must have devoured all that could feed its activity.

Humboldt supposes that the earth is now still cooling from its original state of heat, with depths in which “the materials of which our rocks are composed, exist either in a softened, though still tenacious state, or in complete fusion.” These rocks are not the food of fire, they are the subjects of its action, and, accordingly, Humboldt’s theory is not of a fire constantly burning, but of a molten mass, forming the nucleus or centre of the earth, and which remains unconsolidated, while the outside or upper part of

our planet has been cooled and aggregated into its present solid nature by centrifugal force. "We have considered the compression or ellipticity" (in the figure of the earth) "as a consequence of the centrifugal force acting on a rotating mass, and as evidencing the earlier condition of fluidity in our planet. In the course of the solidification of this fluid—which some have been inclined to assume to have been originally gaseous, and heated to a very high degree of temperature—an enormous quantity of latent heat would have been disengaged; and supposing, with Fourier, the process of consolidation to have commenced by radiation into space from the cooling surface, the particles nearer to the centre of the earth would have continued fluid and incandescent. After long transmission of heat from the centre towards the surface, a stable condition of the temperature would have been established." ("Cosmos," i. 161.)

"Stable condition of temperature!" Why should the temperature continue stable? Why should it become stable, when the mass of molten matter is still in the earth's centre? Why does this mass now continue to retain its heat at the same undiminishing temperature? Is not the centrifugal force still in action? "the length of a day, during an interval of two thousand years, has not diminished the one-hundredth part of a second," nor

"the mean temperature of the earth altered during that period so much as 1-300th of a degree of Fahrenheit's thermometer." ("Cosmos," i. 166.) The reason of this invariability is not explained. He says the heat of the globe arises from the heat of the sun penetrating downwards, or creeping along the interior of the crust from the equatorial to the polar regions, and from "the secular cooling of the terrestrial globe, in the escape of the very small quantity of the primitive heat of the planet which is now given out from its surface." "Cosmos," i. 164.

Yet it is to this internal molten mass that Humboldt attributes our earthquakes and volcanoes: "If we could obtain daily intelligence of the condition of the whole surface of the earth, we should very probably arrive at the conviction, that this surface is almost always shaking at some one point, and that it is incessantly affected by the reaction of the interior against the exterior. The frequency and universality of a phenomenon which probably owes its origin to the high temperature of the interior and deep-seated molten strata, explain its independence of the nature of the rocks in which it manifests itself."*

This mass of heated matter which thus convulses the whole globe, and forces itself to upper air, independent of the nature of the opposing rocks or

* "Cosmos," i. p. 199.

strata through which it pierces, has yet now no influence, he asserts, upon the temperature of the earth; as far as we have penetrated, that remains the same; and this mass continues in this state of fusion, producing the most violent phenomena, and yet undiminished and unincreased,—now, as he says, breaking the barriers of the mightiest superincumbent rocks, and now, (“Cosmos,” i. 203,) interrupted by “the formation of veins, *i. e.* the filling up of fissures with crystalline masses, issuing from the interior, gradually impedes the free escape of elastic fluids.”

Here we have the force of this internal molten mass so powerful in “its accumulated energy” as to force through granitic rocks—to upheave whole continents, and shake and alter the levels of land and sea, while it, at another time, is stopped in its progress by the mere filling up of cracks or fissures in the surface of the earth!

This inconsistency is avoided by the electric theory; because, while it accounts for the vast and general operations of earthquake and volcano, it does not interfere with the lesser and local effects of carbonic consumption observed in coal-mines, or the collections of vapours and gases from chemical combinations in particular places, resulting in fetid waters, like those of Harrogate, or the slow formations of fossils or of stalactites, by the depo-

siting process of watery solutions. Avoiding the inconsistencies and impossibilities of an internal mass of fire, or of molten fiery matter, the electro-magnetic or galvanic action within the globe, while it maintains its rotation, accounts for the disturbances at its surface of earthquakes and volcanoes—"phenomena not less energetic because invisible," as Humboldt says of electro-magnetism, ("Cosmos," i. 149,) although he does not allow to it all the power which my theory attributes to it.

Halley supposed a hollow in the centre of the earth, where a magnetic nucleus perpetually revolved: add to this nucleus, friction. Suppose it a magnetic mass, constantly kept in electric action by moving against the sides of the hollow in which it revolves—a ceaseless friction, producing a ceaseless flow of electro-magnetic power, capable of affecting all the sequent and all the interrupted processes of our globe. This theory is only subject to one objection, the actual mechanical wear of the friction—the impossibility of such a process as constant friction continuing, even as long as our traditionary records extend, without having worn away the outward surface of the revolving nucleus, and the inward surface of the hollow in which it revolved. And also, though this revolving nucleus might come to carry on the rotation of the globe, as a stone inside a cylinder rolls it down an

inclined plane, yet this movement would be complicated, and would involve us in endless difficulties; and, as long as the two magnetic surfaces continued by their friction to produce electricity, there would be a continuous train of electric sparks or fire, which would have kept up a constant succession of electric effects on all sides of the globe at once, producing earthquakes and volcanoes in all parts at the same time; and then, as the spheres wore away, all volcanic phenomena would cease, and the rate of the earth's rotation would perceptibly lessen—all which is contrary to experience.

DION. I wonder that Humboldt should not have adopted this rotating, electrifying nucleus; as, if he could have overlooked these impossibilities, it would have accounted better than his fused mass of molten matter for extinct volcanoes, and for the presence of carbonic formations, containing plants and animals now belonging to warmer latitudes than their geological locus.

ALASTOR. Humboldt's having adopted the theory of gradual cooling, and a still existing mass of uncooled matter, blinded him to the simpler agency of electricity, to which he is inclined to attribute so much, and of whose power he has so just a sense, that it is, as you say, surprising he should have neglected the adaptation of its power as sus-

taining the universe, and as having produced the upheavements of strata and volcanic disturbances of the past, and as still producing the interruption and phenomena which take place at present on our planet.

The reciprocal action of the earth's *internal heat*, according to Humboldt—or, according to my theory of its electro-magnetism—with that of the atmosphere, resulting in the differences of what we call climate, soil, and vegetable and animal life, and varieties of season—this reciprocal action is so affected by local and peculiar circumstances, that the general effect attributed to it by geologists is inadequate; and, to compensate for what is wanting in force, they endeavour to make up in time; and accordingly they are lavish of centuries, and count by thousands and millions of years, to produce, by these atmospheric and internal-heat actions, the vast effects which a single electric stream will produce in a moment.

To produce these effects there is, according to the electro-magnetic theory, in the centre of our globe a combination of materials, whose action on each other is constantly sending forth electro-magnetic force, which, connected by conductors with the magnetic poles of the earth, maintain its constant rotation on its own axis. Were the connexion of these conductors to be broken, the

effect of the galvanic action would cease at once—the earth would be at rest, and constant day or constant night would be the portion of that side of the globe which at that moment stood opposite to the sun.

Why this cessation never occurred—why all these worlds, which we call the planetary system, should be thus moved and thus maintained, is as impenetrable a mystery as why they should ever have existed, or how they were created; and we might, dismayed by the sublimity of this mystery, draw back in hopeless, helpless awe, and say, Almighty Power created these worlds and set them in motion, and we can no more tell how they move, than why they were created.

But man was created too; and a part of his very creation—one of the very essentials of his being—is this WHY? and HOW? To submit in honest consciousness to our incapacity to comprehend the WHY, is the noblest expression of human dignity; while the exertion of every power he possesses—mental, bodily, endowed, or acquired—is devoted to the discovery of the HOW. Undismayed by the vast, undaunted by the complicated, the highest human intellect has struggled on, and struggles still, to comprehend the vast and to explain the complicated. We do not, hopeless and helpless, resign ourselves to the expression—

A power, a force, moves and maintains this planet earth, and the sun, and all the planets of our universe—we seek to define that force. None of the operations of distant planetary movements are more complicated than the structure, the continuance, the succession of the human body: the why the original creation, and the necessary decay, and the inevitable end—that dread mystery of death—are inscrutable; but the secondary action, that *maintains* what we call life, we penetrate and understand; and we know that food supports, and that the blood circulates, and the internal machine is wound up from day to day, and continues to go till all the parts are worn or stiffened or decayed, and bodily life, by slow decrepitude or sudden violence, stops at once, and this wonderful machine is left a mass of matter revolting to behold, and soon to be resolved into the lowest elements of earthy things; and, while shocked humanity looks upon this ghastly change, it irresistibly believes that the intellect, the mind, the thoughts, the feelings—the soul, survives this bodily destruction.

And, reasoning from our capability of understanding and perceiving these secondary means—this mechanism of joints and muscles and nerves, this system of the heart, the blood, the veins, the digestion, and all the functions of animal life—we

seek for secondary action as comprehensible to human capacity in the construction and the maintenance of the planetary universe.

Attraction of gravitation has been this maintaining power ; I substitute for this unmeaning expression of an undefined impulse, the simpler and definable force of magnetism, in which word I comprehend all that we call electro-magnetic, electric, and galvanic action ; and from its central aggregation in our earth are the connecting conductors, the lines of conducting material, which extend from north to south, leaving between them only a space, which we term the axis of our globe,—a vague term, as it would, by analogy of human mechanics, mean an actual central pole, *on* which the mass revolved, whereas we only understand it to be an electro-magnetic sustaining power, *round* which it occasions the rotation of the mass of which it is the centre. Whether this central source of magnetic action was thus placed at once at the creation of our globe, or whether it is the result of successive changes, is in the BEYOND of our human comprehension ; but we can try to understand whether the whole globe was originally a mass of clay—mere earthy matter, and, by continued magnetic or electric action, separated, and combined into the different and now existing forms of water, rock, metallic and carbonic substance ; or whether

these substances have now their final formation, and are now only capable of change in position, or separation in their masses. Are the granitic roots of the Himalayas and the Alps still susceptible of change from this central electric action? are the unfathomed depths of ocean undergoing continued alteration? are the beds of carbonic or metallic formation, in which our deepest mines are but as scratches on their surface—are these still subject to mutability of nature or substance? or were these formations original with the present form and present motion of our globe?

DION. Yes or no?

ALASTOR. Yes. I conceive that, from whatever cause or however occasioned, our globe, from the commencement of its present self-rotatory and sun-gyrating motions, did consist, as it now does, of earthy, rocky, and watery materials, within which exists the electro-magnetic combination, which we may name a galvanic battery; that is to say, the materials from which we produce electro-magnetic action, and which are so combined, so balanced, or so modified, as not only to act, but to reproduce. In upper earth, in animal and vegetable existence, there is this ceaseless production, sustenance, and reproduction—animal from animal: from animal to vegetable, from vegetable to vegetable, and from vegetable to animal again, and

so on, in what is and has been to us a circle of endless reproduction of the same—the varied same existences.

Such power of endless production and reproduction as we behold on the surface, I conceive to exist in the interior of our world. On the surface, we behold these changes and reproductions in organized matter—in the interior, we conceive them to subsist in mineral or earthy materials. By the friction of certain substances, we bring out what we term electric sparks: by the combination of certain materials, as copper, zinc, and acids, we effect what we call galvanic or electro-magnetic action—such combination extending through the centre of our sphere, and existing as long as the sphere itself has power, not only to keep up this constant action, but by that very action to reproduce this productive force. We can, in our little imitative attempts, effect what are to us immense and marvellous changes in the combinations of all the materials on which these electro-magnetic batteries can be made to act. Such effects of such action, enlarged and continued on a scale and to an extent beyond our calculation, are sufficient to keep up the production and reproduction of electro-magnetic material in circling sequence, so as to continue the unvarying rotation of the whole globe, and to furnish throughout its whole mass,

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to its surface, the magnetic influence which we call attraction, causing the descent of all bodies towards that surface, and producing the magnetic effects of the loadstone and the needle in their variable constancies; while the resumption and reproduction of power in the interior are, with constant succession of mutability, discharging those collections of electric heat which force their way to upper air in the shape of melted rock, or lava from volcanoes, or in the fetid waters of so-called medicinal springs, or in boiling geysers, or in innocuous flames, or in the unseen but destructive throes of electrified matter, resulting in earthquakes, to the upheaving or overwhelming of whole regions. The particular localities in which these phenomena appear are inconsistent with the theory of an internal molten mass of heat gradually cooling down: as there is in it no exciting cause for mutability of action, the only change of which we could become sensible would be, that of gradual cessation in all these eruptions—a change which has been thought to be supported by the basaltic remains in various parts of the globe, which were supposed to indicate the former presence of volcanic action to an extent that the cooler internal heat is now incapable of producing; but in this, as in other parts of the *Plutonic* theory, sufficient allowance was not made for local circumstances—for peculiar

formations or strata—for in it, as in all other theories, there is pre-supposed an original formation of earthy matter to be worked upon, either flung from some original planet, or collected from some original mass of heated matter, and formed and cooled by *centrifugal force*—one of those vague, anomalous terms, unmeaning and irrational, which have been used, instead of considering this rotatory motion as the result of electric action—the cause at once and the maintenance of this centrifugal force. This mass of molten matter, according to the Plutonic theory, being whirled into shape, it, in its whirling and its cooling, fell into the state which it at present exhibits to geologists and geographers. The continents, the oceans, the islands, the mountains, plains, and diversified strata,—all these suppose the existence of earthy matter cooled from without, heated from within, and subject to progressive alteration from atmospheric phenomena.

Such pre-supposed existence of earthy matter is essential to all theories; and in that of electromagnetic action, without neglecting the universal influence of the surrounding atmosphere on the surface, it attributes all these interior phases of structure in the globe to this *electric action, proceeding from the central combination of electric production, and acting generally and locally on*

the different forms of earthy matter which it encounters in its passage, and resulting in the metallic, crystalline, carbonic, or basaltic formations now existing; while the still active volcanoes continue to display this electric action on the surface, because the original passage made by the electric rush, meeting originally with no resisting matter, has continued to force a free exit; and the interrupted, fitful recurrence of the eruptions, and the sudden appearance of new volcanoes, and the sensation of new earthquakes, arises from the constantly-generating process of electric force, encountering in its upward passage more or less impediment, as the superimpending masses resist or yield, or burst or fuse before its force.

VIII.

DION. Pacing yesterday evening in philosophic leisure down Christ Church walk, in all the stillness of summer and vacation, I saw the most splendid falling star: it "glided from its stay" so gently, and pursued its path with such serene majesty, till it had disappeared in space!

ALASTOR. How sublime is such a sight, and how

“cribbed, confined, and cabined” appear all our efforts at accounting for it, in the presence of such majestic phenomena!

DION. For which reason, I suppose, you shunned altogether the subject of falling stars, which Humboldt connects so closely with that of meteoric stones?

ALASTOR. I did not refer to them, because I do not connect the two phenomena with each other. Aërolites, you seemed to be convinced, are the results of the sudden descent of electric force from our atmosphere, acting upon encountering matter on the surface of our globe, and thus converting it into the metallic mass which we call aërolites, and which partake in different proportions, according to the nature of the encountering earthy matter, of the same metallic substances as are found embedded in various parts of our globe, formed in those various parts from the upward force of the internal electric force, encountering, as does the downward current of the atmosphere, pre-existing matter, which, when electrically fused, results in iron or nickel, &c. &c. What the nature of these substances so encountered, which, for want of a better appellation, we call earthy—what they might be found to consist of on being subject to chemical analysis, may perhaps be yet discovered; but this discovery by analysis is, in the nature of

the theory, almost impossible: the change is instantaneous and complete in the case of isolated aërolites, and in that of mines or strata the same change has been so complete in such unapproachable distance of time, that every trace of the process has disappeared.

Aërolites are, therefore, wholly unconnected with falling stars, whose mysterious majesty of appearance, singly, as you saw it last night, or in "the brilliant phenomenon of meteoric showers," ("Cosmos," i. p. 125,) may well "move the thoughtful mind to more than contemplation"—to ardent exertion to account for, or at least to arrive at some consistent theory for, these starry travellers in space, and for the more lasting but equally unaccountable phenomenon of comets.

Comets have been observed since the earliest ages of which we possess any recorded knowledge, and yet "their intimate nature, and the offices they perform in the economy of our system, are as much unknown as ever." (Herschel's "Astronomy," p. 300.) What they are, or whence they derive their brilliant light, has not yet been ascertained; they "consist," says Sir John Herschel, "for the most part, of a large and splendid but ill-defined nebulous mass of light, called the head, which is usually much brighter towards its centre, and offers the appearance of a vivid nucleus, like

a star or planet. From the head, and in a direction *opposite to that in which the sun is situated*, from the comet appear to diverge two streams of light, which grow broader and more diffused at a distance from the head, and which sometimes close in and unite at a little distance behind it—sometimes continue distinct for a great part of their course, producing an effect like that of the trains left by some bright meteors, or like the diverging fire of a sky rocket (only without sparks or perceptible motion). This is the tail;” of which, he says, “no rational or even plausible account has yet been rendered.”

And again : when we try to learn the density ascribed to comets, Laplace can only give that of 1770 as “*probably*” less than $\frac{1}{3000}$ of the earth, and the average with “*a certain degree* of probability, to a quantity far below even $\frac{1}{100000}$ of the earth’s mass.” The impossibility of any accurate determinations of the density or the form of comets is evident—and how absurd is the attempt at an exactness which cannot be attained ! Sir John Herschel is more honest, for he ends his chapter on comets thus : “It is time to quit a subject so mysterious, and open to such endless speculation.”—(“Treatise on Astronomy,” p. 312.)

But Humboldt, with less candour, says : “We are indebted to Arago’s polarization experiments

for the most important and decisive observations on the nature of the light of comets. His polariscope instructs us concerning the physical constitution of the sun, as well as that of the comets; it informs us whether a luminous ray, which reaches us from a distance of many millions of miles, is a direct, or a reflected, or refracted ray; and if direct, whether the source of light is a solid, a liquid, or a gaseous body. The light of Capella, and that of the great comet of 1819, were examined at the Paris Observatory with the same apparatus. The comet showed polarized, and therefore reflected light, whilst, as was to be expected, the fixed star was proved to be a self-luminous sun. The existence of polarized cometary light announced itself, not only by the inequality of the images, but was shown with still greater certainty, at the reappearance of Halley's comet in 1835, by the more striking contrast of complementary colours, in accordance with the laws of chromatic polarization discovered by Arago in 1811."

Now you think that matter is set at rest; that the question of comets being self-luminous, or shining with reflected light, was finally answered; that there could no longer be a doubt—comets shine with only a reflected light. Now see Arago's own account of these experiments:—"On doit

conclure de l'ensemble de ces observations, que la lumière de la comète n'était pas en totalité composée de rayons doués des propriétés de la lumière directe, propre, ou assimilée : il s'y trouvait de la lumière réfléchie spéculairement et polarisée—c'est-à-dire, venant du soleil. On ne peut décider par cette méthode, d'une manière absolue, que les comètes brillent seulement d'un éclat d'emprunt. En effet, en devenant lumineux par eux-mêmes, les corps ne perdent pas pour cela la faculté de réfléchir des lumières étrangères."

It is, indeed, as he justly observes, impossible from such statements to decide anything, as Humboldt himself declares : " These fine experiments leave it, however, still undecided whether, besides this reflected solar light, comets may not have a proper light of their own : " this at the end of a paragraph commencing with—" We are indebted to Arago's experiments for the most decisive observations on the nature of the light of comets." (!) (" Cosmos," i. p. 97, and note 51.)

DION. My exact sciences !

ALASTOR. I do not, then, attempt to tell you the density, or to calculate the " length of the axes of a comet's ellipse, which *may be* infinite ; " (Herschel, p. 307;) or to determine, indeterminately, the many millions of miles' length of what is afterwards called a vapour, whose form is acknowledged

to be always varying. I carry out the electro-magnetic system with regard to comets, as well as for the more sedately-travelling planets—the gravitation theory being more than ever incomprehensible when it is applied to such aggregations as comets. How it was supposed to sustain in equilibrium these “almost immaterial” monsters, by the same force that whirled them in eccentric orbits at a rate outspeeding all other planetary bodies, has not been explained. The influence “must be,” says Herschel, “that of the sun.”

It is the influence—the electric influence—which, emanating from the sun, maintains in their extended orbits those planets which are called comets, which consist, according to the electric theory, of an electrified centre or head, charged with electricity to a degree beyond that of any other planet, and discharging from itself a continuous emanation of electric matter, in greater or less proportions, and appearing in such proportions to our view as attended by a greater or less train, or tail, of transparent brightness. Our own planet, earth, her satellite the moon, and all the other discovered or to-be-discovered planets, being constructed with an internal reservoir of electro-magnetic combination, by which the rotation on their own axis is kept up, and from which, in the case of the comets, in their peculiar formation, is kept up their own

brightness and that of their attendant clouds of light. Why their ellipse should be so eccentric is no more in our power to ascertain, than why Mercury should be near, and Saturn far from the sun.

One of the axioms of the electro-magnetic theory of the universe is, THAT THE MAGNETIC ATTRACTION IN EACH PLANET IS CONFINED TO ITS OWN ATMOSPHERE—that is to say, that it extends no further from each planet, than the extent from earth of our atmosphere. We will not now go into the question of atmosphere or no atmosphere for the moon and all other planets; but this principle of non-extension of magnetic attraction beyond its own immediate sphere in each planet is necessarily contained in, and forming an essential part of, the theory of electric maintenance of these planets in their orbits; for all the known and all the yet-to-be-discovered sun-gyrating bodies depend in their motions on the sun; and were their own masses magnetic beyond their own immediate atmosphere, or surrounding space, this magnetic attraction would at once draw them towards the centre sun, the gyration would cease, and the universe be annihilated. The gyrations of the planetary universe depend on the repellent attraction, or opposing polarity, which causes a body, in itself magnetic, to revolve while under the

influence of this electro-magnetic or galvanic agency ; and to maintain this agency, the bodies upon which it acts are projected beyond the influence of mere magnetic attraction ; and having been so projected, (always having to GRANT the CREATIVE projection,) the constantly-acting source of electric agency holds all those bodies which we usually call the planets in their unvarying course round itself, with their surrounding satellites. But comets, which are not usually called planets, can only be so called because of their ellipsoidal gyrations round the sun ; in all else they differ from the other so-called planets : they are essentially in themselves sources or masses of electro-magnetic agency, whose activity is not, as in the earth, confined to the internal centre, and affecting only its own surface through its own mass. The comet, whatever may be the relative extent of its central source, sends from it, not only the light or blaze of this central electric activity, but throws from it a stream or shower more or less vivid, according to the greater or weaker action of this *electrical machine*, and appearing more or less brilliant as it recedes from or nears the sun. The rapid apparent contraction of its tail, or attendant shower, observed on its approach to the sun, and "the equally rapid dilatation as it recedes," are only apparent ; that is to say, that

the minute sparks which form the showery tail or dishevelled hair attendant on the comet, lose, to our sight, their brilliancy in the more vivid blaze of the solar action—a brilliancy which is recovered as the comet again recedes in its path from the immediate solar blaze. This natural method of accounting for the diminished light of comets was impossible on the theory of their reflected or borrowed solar light.

But look here, Dion; read these two passages in these two books—Herschel's "Astronomy," and Humboldt's "Cosmos." This treatise on astronomy was printed in 1833; and speaking of Halley's comet, whose re-appearance in 1759 so remarkably fulfilled his prophecy, Herschel says, "Its next return to the perihelion has been calculated by Messrs. Demoiseau and Pontecoulant, and fixed by the former on the 4th, and, by the latter, on the 7th of November, 1835."—p. 308.

Now look in the first volume of "Cosmos," at page 94: "These changes have been well described in Halley's comet, on its last re-appearance in 1835, by Bessel, at Königsberg."

DION. This sort of unconscious, unpremeditated, accidental confirmation in the works of these two great philosophers, is very admirable, and it must convince even you that there is exactness in science.

ALASTOR. I never questioned it, where founded upon observation and corroborated by actual definite numbers. I began, you may remember, by declaring my admiration for scientific research: and what have we been doing, in all our conversations on this electric theory, but endeavouring to follow out the discoveries and experiments in this science by extending it to the planetary universe? All that I contend, and which I do constantly take every opportunity of showing, is, that no science except that of Number can ever claim the presumptuous epithet of exact. Here, even while pointing out to you Humboldt's incidental corroboration of Herschel's passing mention of a comet's expected re-appearance, I observe in Herschel's "Astronomy" these inexact expressions:—"Comets in passing among and near the planets are materially drawn aside from their courses, and in some cases have their orbits entirely changed. This is remarkably the case with Jupiter, which seems, by some strange fatality, to be constantly in their way, and to serve as a perpetual stumbling-block to them."

It is unworthy of a philosopher, in a scientific work, to talk of fatality, or of one planet being a stumbling-block to another. And this instance of Lexell's comet of 1770 is a remarkable instance of inexact exactness: its return in five years was pre-

dicted, but "the prediction was disappointed by the comet actually getting entangled among the satellites of Jupiter, and being completely thrown out of its orbit by the attraction of that planet."—p. 310.

Now this *accidental* rencounter is irreconcilable with the statement (p. 308) of Clairaut's calculating, for Halley's comet, the exact number of days that it would be delayed in its journey by Saturn and by Jupiter.

DION. On the contrary, it only proves that Clairaut was a more profound calculator than Lexell, who, from not allowing for the attraction of gravitation in these planets, mistook the time of its reappearance.

ALASTOR. Yes, that is the form in which Herschel should have stated it—while I refer these retardations in time and alterations in orbit to the actual construction of the body cometic, which, not being spheres revolving on their own axes, do not consist of a mass of matter containing in its centre a galvanic reservoir, whence conductors to the magnetic poles maintain the rotatory motion on its own axis, but they are formed of a diaphanous revolver on a solid interior, producing in its revolutions a constant electric action, resulting in the coma, or shower of light—in some comets drawn behind, in some projected before, in some at once preceding and following the central agency. And

as, from their formation, the constant action of the outside revolver must wear away itself and the interior nucleus, accordingly we find that those comets which have re-appeared exhibit at each successive re-appearance "successive degradations of its apparent size and the length of its tail" (Herschel's "Astronomy," p. 308); by which successive degradations the actual form and being of the comet are worn away, till it ceases to give forth any sparks; its light fades, disappears, and, to our ken, it *dies*—its soulless or unenlightened frame still pursuing its, to us unseen, eccentric gyrations, till its final extinction. This *death* of the comets is consistent with their appearance, and with the theory of their MECHANICAL formation; differing from the chemical construction of the other planets, furnished with interior self-reviving electro-magnetic or galvanic reservoirs: while this theory of their death to us, and their for a time continued bodily existence, a mass of revolving matter in their prescribed orbits, is more consistent than the supposition, that should a comet's "orbit be of the hyperbolic character, when once it had passed its perihelion it could never more return within the sphere of our observation, but must run off to visit other systems, or be lost in the immensity of space."

Here are two wild expressions—"visit other

systems," as an ex-chancellor might make a trip to France; or "be lost in the immensity of space."—(Herschel, p. 307.)

DION. What is SPACE, used in this sense as a beyond of our universe?

ALASTOR. We will talk of that presently; but let us finish with comets, for one remarkable anomaly in their history we have not touched upon—that of their course being in some instances (the famous one called Halley's comet in particular) retrograde, or in a contrary direction to that of all other planetary bodies. How does this agree with the attraction of gravitation, which is drawing all other bodies in a contrary direction? And why, on its return in 1759, was its period altered? Its "expected return would happen later than on the supposition of its retaining an unaltered period." (Herschel, p. 308.) Why was its period altered? Had not it passed as near Saturn and Jupiter before? or, if it had not, why did it do so now? What had, on the gravitation theory, altered its orbit? If its orbit was altered, how could its course be calculated on the data of its former appearances?

Its retrograde or contrary motion, which is inconsistent with the laws of gravity, becomes a simple fact according to those of the electric theory: its magnetic pole is reversed, and the

attraction, therefore, draws it in a direction opposite to that followed by the regular planets

The supposed retardation by the attraction of Saturn and Jupiter is in theory false—as supposing an alteration which contradicts the very proposition it sets forth,—and in practice incorrect, as the calculations declare a certain exact number of days' delay, 100 for Saturn and 518 for Jupiter, and make the result an uncertain “one way or another”—80 days more or less.

As to the comet of 1770 (Lexell's) becoming “entangled among Jupiter's satellites,”—as if some thoughtless Phaëton had got the reins, and, attempting to dash in and “cut the line,” had smashed a back panel, or broken his own traces, or locked his wheels among the others—so absurd and unscientific are the terms in which this is expressed,—the periodic returns of these comets can be calculated, and have been proved to be rightly so; that is to say, not with affected exactness, but near enough to prove the calculation true. Their return, then, is periodic: is it consistent with any system to suppose an *accidental* change of orbit? But the fact was, that Lexell's comet never did re-appear; that it wore out its light, died, and, though it returned in due time into our field of view, it was no longer visible to us; while the comet seen to pass (not entangle

itself in) the satellites of Jupiter, was another and altogether different body. For all the comets hitherto observed, or yet to be discovered, have been in motion ever since the projection of our planetary universe, revolving in their extended orbits till they come within our view, and then pass away—either with such swiftness (for the comet of 1472 passed through 120 degrees in one day) that they have eluded observation; or, wearing out, they fade, darken, and disappear from our view, till, all electric action ceasing, their nucleus becomes by degrees unpolarized, the magnetic attraction of its own mass gradually decays, the sun's electric force begins to influence, not the mass, but its component parts, till they are at last finally separated and dissolved by the sun's galvanic action, and amalgamated into that mass of electro-magnetic action.

A more philosophic and consistent end than that of "falling into the sun," as Herschel words it; and this, their gradual cessation of electric action, being a simpler and more systematic explanation of the gradual fading of their light and narrowing of their orbit than the intrusion of that which, according to Encke, retards its progress by diminishing its centrifugal force—"a rare ethereal medium." (Herschel, p. 309.) What is this ether? what this medium, so rare as not to inter-

fere with observations from the earth, and yet so powerful as to clog the motions of a body whose attendant train extends millions of miles?

This gradual separation of and absorption into the sun's electric source of action, occasion what are called the spots in the sun, which appear and disappear in a manner hitherto so unaccountable. They are the attracted materials of dead comets in the process of galvanic action, or resolution into the sun's reservoir.

Another anomaly in the planetary system has hitherto been allowed to pass unexplained into all the received astronomical theories—what are called SATURN'S RINGS. How these great and disproportioned masses are supposed to be sustained—so different as they are from all the other heavenly bodies—according to the law of gravity, has not been explained. These rings are, according to Herschel, "solid opaque substances," the exterior diameter of the exterior ring being 176,418 miles, and that of the interior 151,690 miles, their thickness not exceeding 100 miles. "It will naturally be asked how so stupendous an arch, if composed of solid and ponderous materials, can be sustained without collapsing and falling in upon the planet? The answer to this is to be found in the swift rotation of the ring in its own plane, which observation has detected, owing to some

portion of the ring being a *little less* bright than others, and assigned its period at 10 hours 29 min. 17 sec., which, from what we know of its dimensions, and of the force of gravity in the Saturnian system, is *very nearly* the periodio time of a satellite revolving, at the same distance from the middle of its breadth. It is the centrifugal force, then, arising from this rotation, which sustains it." —"Treatise on Astronomy," p. 284.

These rings are, then, sustained, according to Sir John Herschel, by their centrifugal force, and "the force of gravity in the Saturnian system." What is the force of gravity in a body which he tells us (p. 278) "consists of materials not much heavier than cork"? But "the force of gravity is in the volume, not the mass," a proposition which we questioned before, without coming to any explanation; so we will not go further into Sir John's attempts at solution for the problem of Saturn's rings,—"*loading*" to make them "stable," of "whose existence," he then says, "we have no proof," in which he "thinks we perceive a sufficient guarantee of its preservation,"—but turn to Humboldt, who regards "Saturn's rings as belts formed of an aggregation of satellites."—(*Cosmos*, i. p. 90.)

Not an aggregation of many satellites, but the continuous motion of one in each orbit, forming the two rings, the rapidity of the motion of these

self-enlightened bodies being such as to give them, to our observation, the appearance of continuous rings.

DION. Herschel says the rings themselves have, by observation, a periodic movement.

ALASTOR. I place no reliance on observations made in such inaccurate terms as "some portions of the ring being a *little less* bright," and "*very nearly* the periodic term of a satellite." I do not believe that what are called Saturn's rings are solid masses, of annular form, but *the paths of revolving satellites, pursuing their course by electric suspension with a rapidity which eludes our observation, and presents them to our view as continuous rings; while comets, formed of a diaphanous cylinder, revolving on a solid nucleus, and thus producing their own light and hastening their own rate of motion, are, like all other planetary bodies, sustained in the orbits assigned to them by original creation, and their rate or periodic times preserved as originally given, at their creative projection, by the electric agency of the solar electromagnetic mass, in whose encompassing electric volume all these bodies move — comets differing from all the rest by their mechanical structure, which wears itself away, causing the gradual fading of the continuous central light produced by the electric friction, and of the trains of attendant electric sparks of light, till their extinction, loss of polarity,*

internal magnetic attraction, the disintegration of their component parts, and final absorption into the solar mass :

The self-luminous nature of the satellites of Saturn, forming those luminous (apparent) rings, arising from the diaphanous nature of their substance disclosing the electro-magnetic light emitted in their central reservoir.

IX.

ALASTOR. What is space? You say, "Space is a necessary notion, *à priori*, which lies at the foundation of all outward phenomena. (Kant, "Critik der reinen Vernunft," i. Theil, 1 Abschnitt). We cannot divest ourselves of this essential to all visible form; there is in our very being an impossibility of conceiving material form without the notion of its occupying space; and wherever we see two or more objects, the inevitable concomitant notion is of space *between* these objects: the expression necessarily implying relation and interval. Take the widest acceptation of the term—suspended in space; this space is to us the interval between ourselves and the horizon, or the zenith. The expression "fall into space" appears sublime, be-

cause it approaches to what is the highest effort of human conception—immaterial existence. But when we consider this expression, what does it mean? It implies a beyond our visual knowledge; but as used by Herschel, for the disappearance from our system of the material aggregate, a comet,—suppose its composition to be ever so rare—gaseous, vapoury, ethereal, or whatever other term we use to define rarity of matter,—still it is material, and, as material, *occupies* space. Then we say “boundless” space—but what meaning does “boundless” convey to the human mind? We drive this comet into space—that is, we suppose it to be beyond our universe: but what is this beyond? This outcast body is still supposed to exist; it exists, then, in relation to our universe; there is between it and the bounds of our universe an interval: we enlarge the interval, we drive it further, but what do we mean? That this beyond is Nothingness? We stop, and we perceive that we have passed the power of human thought. Falling INTO space implies a boundary—implies, that all we can attempt to express by space is an interval, more or less extended; but extend it as far as human thought extends, it is still a bounded interval; and such is what we mean by our system—our universe. “Beyond the bounds of the universe,” is only a confession of our bounded

conception. All that is apprehensible to our faculties is what we call our universe; and when we speak of beyond, we are stopped at once—we come to the incomprehensible.

Speaking of our cosmos, we mean, according to Hegel, “external phenomena translated into our internal representation of them;” or, “the *contents of space* the distribution of the material universe,” as Humboldt defines it, including all that human science has made apparent to the human senses, as well as all that these unassisted senses comprehend of outward material and organic phenomena, and of inward sensation and thought, and all that belongs to human life.

“We see matter existing in space,” says Humboldt, (“Cosmos,” i. p. 73,) as he begins his description of the planetary system—but he does not define what he means by space. He does not state the fact, that all our space is the interval between our stand upon this earth, and that “blue vault of heaven” which, when all intervening atmospheric obstruction of clouds and mists is cleared away, is and has ever been to man the limit of his material apprehension. It is within this interval between earth and sky that our universe exists.

The sky! a word we use incessantly—what does it—what should it mean?—Come out into the garden—and now—

CIRCUMSPICE !

—There is the sky—there is the steadfast bear, and there are all those bright creations—those aggregates of electric matter, which, like the sun—whether fragments of some anterior and greater aggregate of electric matter, or originally created as we now see them—are now balanced in their electric ocean in those stations where we, and where all our predecessors, have observed them. I say *ocean* advisedly: I mean that what we call in common parlance the air and æther, or in your *exact science indefinite space*, sustains these rarefied combinations of electric light and heat in their constancy unmoved, and independent of the planetary system—of those ancient travellers whose courses have been known as long as human thought, and of those new-found gyrators round that heat-rarefied electric-balanced centre sun. Independent of and undisturbed by these influences, these stationary lights remain—not hung, for that implies a somewhat to which they hang—but balanced and sustained in their electric medium—a medium which is always exercising its electro-magnetic power, and from whence proceed those sublime emanations which are called falling stars. These sudden productions of the ever-working electricity—unlike the fixed stars, a rarefied apparatus of incessant electric light, balanced to permanency—rush from

their origin, unrarefied, to that consistency which the electric medium can support, and are reabsorbed in it: not, in the unmeaning phraseology of so-called science, "projected into space," but re-attracted into their electric source; and their increased number, or the showers of these beautiful productions in August and November, are not, as has been supposed, "travelling aggregates of meteoric stars, whose path is intersected at those seasons by the earth," but are to us apparent on those days, because we are then in view of that portion of the electric medium where the combinations are in most activity, and whence dart, or glide, or burst those living lights which make these nights so celebrated.

The confounding what are called fire-balls or meteors with falling stars, is to confound terrestrial with what, for want of a better word, we call celestial phenomena. Fire-balls, meteors and meteoric stones, and northern lights, are electrical combinations in our terrestrial atmosphere, and their results are on our terrestrial surface. Falling stars are combinations in an electric medium beyond our atmosphere, resulting in that medium and confined to it.

The Milky Way is not, as Aristotle supposed, a sort of incessantly-reproducing comet; but, as observation proves, a closely-combined extent of

perfectly-balanced combinations of electric power—as the larger fixed stars, self-luminous and undisturbed—as, too, the zodiacal light, which, as Humboldt says, “rises in a pyramidal form, and constantly adorns the tropical nights with its mild radiance,” and which, rising direct from the electric source in unobstructed purity, is visible as sunlight ceases in those portions of the electric medium which we behold from what we call our tropics.

Altogether different are, as I have said, the phenomena of the aurora or polar lights belonging to our atmosphere, or what Humboldt calls “the region of clouds.” “Low down,” he says, “on the horizon, about the part where it is intersected by the magnetic meridian, the sky, which was previously clear, is darkened by an appearance resembling a dense bank or haze,”—“in high northern latitudes, in the near vicinity of the magnetic pole, appearing less dark.”—“The more intense the discharges of the aurora, the more vivid is the play of colours, from violet and bluish-white through all the gradations to green and crimson. In the common electricity excited by friction, it is also found that the spark becomes coloured only when a violent explosion follows high tension.”—“The connexion of the polar light with the most delicate cirrous clouds deserves particular attention, because

it shows us the electro-magnetic light as part of a meteorological process. The magnetism of the earth is here exhibited in its influence on the atmosphere."—("Cosmos," i. p. 182.)

The magnetism of the earth on its atmosphere, and of the electro-magnetic particles of this atmosphere on each other, produces all these aurora, the colours being perceptible only in the night; but "these clouds sometimes arrange themselves in the day-time, like the rays of the aurora, and in such cases the movements of the needle are similarly affected by them. After a great display of aurora there have been recognised, early in the morning, the same streaks of clouds which had before been luminous"—appearances which, like the aurora, are pronounced by meteorologists as precursive of wild weather.

"When it is stated that auroras decrease in frequency and brilliancy with decreasing latitude, it must be understood of magnetic latitude. Whilst an aurora is a very rare occurrence in Italy, it is extremely common in the same latitude in Philadelphia, owing to the vicinity of the American magnetic pole."

Here the most extended observations are in accordance with the consistency of the electric theory of the universe.

DION. What do you understand by the "American magnetic pole?"

ALASTOR. Humboldt says that "the name of *magnetic poles* has been applied to those points on the earth's surface where the horizontal force disappears, and to these points more importance has been attached than properly belongs to them." Truly so, because the variations of the needle are, as I have said, dependent on so many local and atmospheric influences, that it is only confusing and encumbering our definitions to refer these variations to separate poles; they are caused by increased or diminished aggregations of magnetic matter in the earth, or of electro-magnetic vivacity in the air, while the poles, properly speaking, are the culminating points of our internal magnetic influence—the connecting point of our conducting circle.

The *horary variations* of the needle's declination, which are, in the theory of gravity, said to be "governed by the sun, whilst that body is above the horizon at any spot, they also decrease in angular value with the decrease of magnetic latitude; near the equator they barely amount to three or four minutes, while in middle Europe they attain to thirteen or fourteen minutes."—"Cosmos," i. p. 172.)

Why should the sun have less influence where the magnetic force is least? To be consistent with itself—this principle of the sun's influence on the needle's variations—it should increase where

the magnetic attraction of the earth is least—at the equator—and decrease where it approaches the magnetic pole ; but the contrary is found to be the case, as this horary variation, in fact, arises from the earth's horary motion, which, carrying the needle with it in the northern hemisphere, and altering its relation to the magnetic pole, diverts it from its direct polarity—a tendency which is of course fainter at the equator ; and as the needle recovers its balance between the motion and the electric attraction of the earth, the variation diminishes till it ceases in each locality—to return again with the diurnal rotation.

The fixed stars, then, are aggregates of electromagnetism, combined and rarefied till perfectly balanced, where they have been observed since the commencement of human observation, self-luminous and undisturbed, in the electric medium, which is ever active, and from whence proceed and are absorbed the falling stars, unrarefied and unbalanced, into their originating medium ; while the zodiacal light is a constantly-emanating, but unmoving formation from the electric source, the medium where the fixed stars rest. Auroras are results of earthly atmospheric electricity.

X.

DION. You would not, then, use the word space for what is outside of our earth and your electric medium?

ALASTOR. For want of any other word I might do so, but, I think, improperly; space, to human apprehension, being interval between objects: but to say that if we passed through this bounding of our universe we should enter into space, would not so truly express my sense of sublime incomprehensibility as to say we should become aware of a Beyond. But in all that I have said I am, though *in nominibus differentes*, yet *in re congruentes*.

DION. Something more than difference of name, I must say, I think you propose.

ALASTOR. I substitute the positive of a known power for an unknown—the real for the imaginary. Electricity in all its forms has been more or less known, as long as we have any recorded traces of human observation or inquiry; its powerful agencies have been more fully revealed to us by modern experiments, while its mysterious subtilty has hitherto eluded all explanation. To this agency, which, however mysterious, is still known, and its potency acknowledged in many cosmical

phenomena—to this I refer the planetary or solar system, instead of to the unknown “centre of gravity,” “centrifugal force,” and “attraction of cohesion,” which lull, without satisfying research. Such meaningless expressions only say, in other words, that the sun, moon, stars, and earth are maintained in their positions and their courses “SOMEHOW”—this somehow involving all cosmical science in inextricable difficulties; instead of which, I consider centrifugal force as no more than the continuance of an impulsive motion, which continuance is proportioned to this initial motion; but I do not consider centrifugal force a maintaining agency in the system of the universe. Nor am I satisfied with the “somehow” implied in attraction of cohesion—which is only saying, in other words, that the particles of matter stick together because—they stick together. But all the particles composing any aggregate or body of matter, being in themselves electro-magnetic, though in most matter insensible to our apprehension, and not to be affected by any electric agency which we can use (hence the formula of “non-conducting” bodies)—all particles are magnetically attracted to each other; and in the proportion or balance of these attractions towards each other in all material particles, are formed aggregates of matter; and in the proportion or balance of those attracted particles with

the attraction of other aggregated particles and with the attraction of the earth itself, is all that was expressed by attraction of cohesion.

What magnetic attraction *is*, we know not ; but we know that there exists such a power—such a reality, and so we relieve ourselves from the fiction of cohesion.

Then, to explain “why an apple falls,” the explainers were obliged to destroy one fiction by another. There was the fiction or imaginary power of *attraction of cohesion*, by which an apple adhered to its stalk. To get it off this stalk, there was invented the next imaginary power—*attraction of gravitation* ; while in the electro-magnetic theory we have to do only with realities. Instead of inventing one power to conquer another, we use the power we have, of magnetic attraction, which, as long as it remains in the undisturbed relative balance of attraction in its component particles, the form or body which those particles compose remains in its homogeneity. As soon as the influence of greater magnetic attraction suddenly, or by gradual influence, overcomes, by altering, the balance or proportion of combining attractiveness, and causes those effects attributed to gravity—or where the homogeneity of matter is destroyed or severed by mechanical means, the situation or condition of the divided parts depends

on the force of the terrestrial against the particular attractions.

DION. In other words, if you saw a tree across it will fall whole to the ground, as its whole preserves the proportion of its particular attractions. But if you blow it to pieces with gunpowder, the proportion of all the attractions is altered.

ALASTOR. Altered, but not destroyed—the wood, though separated, is still wood; whereas, in chemical action, the elective affinities are so excited as not only to alter but to destroy the original proportions of magnetic adhesion, and to transform these particles into adhesions of a different homogeneity.

You observe that I have not meddled with any chemical agencies. Into the domain of heat and water, and gases and acids, or organic life, I have not attempted to enter—I only say that what chemical agency has to overcome in material combination, is not imaginary cohesion, but actual magnetic attraction.

I have attacked your term of exact, when applied to cosmical science, because exactness has not been attained in these sciences; but though I have contradicted their theories, I have not meant to attack the men whose works we have been studying. Humboldt and Herschel are not only men of the first genius, and of universal acquire-

ments, but they have employed their genius and their acquirements in the noblest manner—to the highest ends. Their devotion to science and their honesty of purpose are unimpeachable. I contradict the science—not the men. I disallow the assertions which have been received as immutable truths—not as the assertions of this or that philosopher, but as inconsistent in themselves, and incompatible with the phenomena of the universe. I do not intend to overturn anything—I would only substitute the consistent in place of the inconsistent; and in changing the term of the theory of the world, I do not attack anything very fixed or stable, for Sir John Herschel, in his “Treatise on Astronomy,” says (p. 246): “If we abandon the earth as a centre of the planetary motions, it cannot admit of a moment’s hesitation where we should place that centre with the greatest probability of truth. It must surely be the sun which is entitled to the first trial, as a station to which to refer them. If it be not connected with them by any physical relation, it at least possesses the advantage, which the earth does not, of comparative immobility.”

The sun is here only admitted doubtfully to a *trial* for the place of centre to the planetary system.

And (p. 233), as I showed to you the other day: “All bodies with which we are acquainted, when

raised into the air and quietly abandoned, descend to the earth's surface in lines perpendicular to it. They are, therefore, urged thereto by a force or effort, the direct or indirect result of a *consciousness* and a *will* existing *somewhere*, though beyond our power to trace, which force we term *gravity*."

This force existing *somewhere*, I do not term gravity, but magnetic attraction, and its somewhere is in the actual globe itself—a physical and known power, physically acting—a material agency—on matter—not as here stated, with a strange confusion between the created agent and the creative original! Attraction (whether of gravity or of magnetism) has no *will*, no *consciousness*—terms inapplicable to material agency.

When we find that the very foundation of the gravitation theory is thus loosely stated, we leave it and the complicated contradictions of the earth's attraction to the moon, and the moon's to the earth, and their mutual attraction to the sun, whose force is "directly proportioned to its *mass*;" and when we come to compare the "*mass* of the sun with its *bulk*, we find its density to be less than that of the earth;"—leaving, I say, all these inextricable contradictions and confusion of words, we go to the direct agency, the known material power; and we consider the electric medium surrounding our earth—which, when not obscured by our atmo-

spheric clouds, we call the sky—not to be an illusion, because such is the apparent horizon of our view, the boundary to us of earth and sky: this SURROUNDING is the situation of the fixed and falling stars of the milky way and of the zodiacal light.

This medium, antique fable delighted to people with strange poetic monstrosities; but Humboldt thinks not scorn to refer to the philosophers of that antique time for many a sublime speculation; and it is not humiliating, but ennobling, to the human mind, to find how much and how little Chaldean and Grecian philosophy, and all the learning of the Egyptian, effected. It would be humiliating and painful to think of these great men of their day having spent their lives in false philosophy, and having been by their contemporaries looked up to with veneration for their vain reasoning; while it would be as humiliatingly painful to think that, in all the succeeding ages of study, man had advanced no further, made no additions to his knowledge, and reached no nearer to eternal truth. Humboldt accordingly, in his all-embracing "Cosmos," awards an equal tribute of admiration to the ingenious speculations of ancient, and to the experimental research of modern science, although he is too much disposed to undervalue the wonderful accuracy of

observation made by men unprovided as the ancients were with our instruments.

Modern experiments have revealed to us with certainty the long-suspected connexion between magnetism and electricity; and on this connexion depends the theory of the universe. The sky is the electro-magnetic medium, whose original creation and maintaining power have ever been, and still are, inscrutable; but the recognising it as an existent reality brings to consistency the system of our universe, abandons the confusion of a mental and a material heaven, and destroys the inaccuracy of unrestricted space, in which were supposed to move, in unrestrained confusion, comets, and meteors, and aërolites, and floating gases, and impeding ethers, along with the admirable harmony of the sun and its planets.

By getting rid of the perturbations of gravity, we avoid the attempts at incalculable calculations: for all the millions and billions of miles which are given to distances and to magnitudes by astronomers convey no definite ideas, any more than stars that have died before their light reached earth, or density that is lightness, or any of these attempts at reconciling the irreconcilable, which disappear before the controlling influence of definite material agencies.

This surrounding electro-magnetic power sus-

tains the sun, a magnetic combination of electric activity evolving heat and light in itself, and by the extension and expansion of its electric power sustaining in electric revolution the whole multitude of the planets, each in its orbit; while satellites or smaller planets are, by the same solar electric influence, enlightened and revolved round the larger planets, each of which is self-rotatory on magnetic poles, acting by the internal electro-magnetic agency upon the reproductory materials of these bodies.

Among these planets are the comets, self-rotatory and self-luminous by an internal mechanical electric rotation, which, by the gradual wearing away of its materiality, decays, and darkens, and dies.

The earth, as one of the planets, is rotative, from an internal apparatus of self-regenerating electro-magnetic agency—a galvanic battery always in activity, and always depositing the materials which it evolves, in the combinations which its activity induces from the surrounding materials of earth's internal structure. This apparatus, or electro-magnetic agency, in its renewing exertions, becomes more or less vigorous in its activity, according to the deposit or the combination that it works upon; and thus it discovers itself through the earth's surface to the observation of mankind,

in all the volcanic phenomena hitherto referred to water, or to heat, or to both together—neither being in the electric theory the agents, but the results—electro-magnetic action evolving heat, and, in combination, producing hydrogen, the basis of water.

The tides, their ebb and their flow, their regularity and their irregularity, have been, on the theory of gravitation, an insuperable difficulty to men of science. By the electric theory, they are made to depend on the magnetic action of the earth in its rotation drawing towards itself the waters of the sea, while the magnetic influence of the earth below the tidal wave, and of continents on the other side of it, occasions its periodic regularity ; while the local excess of magnetic attraction increases it constantly in some places ; while the want of local magnetism causes its absence altogether in other places ; and an accession from the internal reservoir of magnetic force at some times occasions the extraordinary high tides ; while in some situations, such as the Mediterranean, the opposite shores are so completely balanced in their magnetic attraction as to nullify each other, and to leave it a tideless sea. But at the head of the Adriatic Gulf is a perceptible tide—owing to the greater mass of magnetic attraction in the local nature of that shore.

The moon has been supposed to exercise her

influence, not only on the tides, but upon the meteorological, and even upon the bodily phenomena incident to earth's inhabitants—of all which she is, according to the magnetic theory, completely innocent. She, like other satellites, and other planets, proceeds in her own orbit, altogether independent each of the other: so that, for meteorological and medical phenomena connected with humanity, some other cause than the moon must be referred to.

Invisible light, which makes all things visible, has occupied in vain the attention of the greatest men—of Newton and of Herschel: in vain, because, though almost an essential of our existence, it is of so subtle a nature, that though night and day, and sunshine and lamplight, seem simple facts, yet what this simple essential is, how propagated, or how conveyed, is still a mystery; and we can only assist its elucidation by the certainty which experiments on polarized light have given—that light is, as according to the magnetic theory of the earth it must be, electric—proved by the rotatory movement observed in particular liquids, under the influence of particular separated rays.

TO ASSIST ELUCIDATION is my aim in this magnetic theory of the universe. Instead of attempted exactness in the minutiae of inconsistent parts, or

in the vastness of inscrutable magnitude, I base upon known experiments, upon practical discovery, a theoretic truth, by which we ELUCIDATE some of the mysterious difficulties of our universe, as thus:—

Instead of changing the sky into the retina of the eye, and making a reality an imagination,—instead of narrowing this sky or celestial vault to the extent of our vision—the horizon of our individual position on the globe,—the magnetic theory makes a surrounding electric, sustaining power, a magnetic medium, in which are maintained the fixed stars, and from and in which pass before our sight the falling, or, more properly, travelling, stars—celestial meteors—results of celestial electric agency.

Instead of gravity supporting and confusing, and centrifugal force “somehow” keeping up the revolution of the planets and the comets let loose among them, we have the sun supported in the magnetic medium, and this sun, itself a combination of magnetic electricity, emitting heat and light, and pervading with its electric potency the whole surrounding source, in which the sun’s electric agency sustains the planetary system in their electro-magnetic gyrations; while the internal electro-magnetic conjoined conductors of each planet maintain their ceaseless self-rotation by their chemical electricity, or reproducing galvanism; and the comets

with their mechanical agency of electrical production, furnishing its showery halo and exciting its rapidity of course till it, exhausted, dies, and is, particle by particle, absorbed into the sun.

Instead of the moon, whose existence and movements are constantly being referred to for the inconstant weather or the irregular tides on our earth, we make the moon hold her own gyrations, uninterfered with and uninterfering—our meteorological phenomena depending solely on our atmosphere, and the surface and interior of our own globe, and the tides being the result of the magnetic attraction of a whole continent, or of a particular shore—overcoming, till overcome by, the magnetic attraction of the sea, and its terrestrial foundation.

Instead of the pressure of the atmosphere, when clear and rare, weighing down the mercury in a barometer's fountain, and forcing it to rise in the tube, and when the air is heavy with fog and windy rain, and the clouds touching the earth, pressing less upon the mercury in the fountain, and causing it to fall in the tube, we have the increased magnetic attraction of thunder, misty, rainy storms drawing down the mercury, and causing its fall when stationary; and, when used for measurement, affected in like manner by the increased magnetism of compacted masses of magnetic matter.

Instead of aërolites, little collections of mineral combinations, dropping, unbroken and unburied, on our earth's surface from unlimited space with enormous velocity, we have rushes of lightning or electric meteors formed in the terrestrial atmosphere, which are of such violence and magnitude as to be attracted to the surface of the earth, and falling there—if on a mass of earthy matter containing the combining elements, it results in that combination of electric agency and earthy substance called an aërolite.

Instead of a never-cooling lake of molten matter in earth's centre, producing earthquakes and volcanoes, &c., we have an internal, constantly active, and reproducing electro-magnetic agency, combining by its conductors the opposite poles, and producing, not only the diurnal rotation of the globe, but, in the increase and decrease and periodic recurrence of electro-magnetic formation, and its effects upon the interior substance of the earth, causing volcanoes, earthquakes, and all such disturbances of our surface.

We have, as the cause (not the inscrutable origin) of all celestial and terrestrial phenomena, a consistent theory, based upon a known reality of power, instead of an inconsistent hypothesis based upon an unreal assumption, attempted to be proved by inconclusive inaccuracies of approximative calculations.

DION. There may be, perhaps, by improved instruments, or by increased facility of observation, a possibility of proving the truth of your speculations, which, though founded on a known power, are so wide and extended.

ALASTOR. Their extended generalization is their truth.

DION. Nevertheless, and in spite of all your overturning of the exactness of my exact sciences, I shall not give my assent to your system till, as I said before, I have seen it submitted to, and standing the test of, the most rigorous analysis.

ALASTOR. Nor shall I be satisfied with any other analysis, or any other test, and I leave it fearlessly to such examination and such tests; but the state of scientific test must be very different from what it now is, before such tests will arrive at any real definite proof. I shall not be satisfied with *approximations*, or *nearly*, or with a "so-called law" (Kepler's) "of the distances of the planets from the sun, which has been found numerically inexact for the distances between Mercury, Venus, and the Earth, and requires an arbitrary supposition in the first member of the series." ("Cosmos," i. p. 86.) I will have no "arbitrary suppositions." I will take no mere authority, nor shall I be contented to be told, that "whoever will take the trouble to go through the calculation will find" "that the expression of Kepler's laws" (the

most remarkable, and the most pregnant with important consequences, to which induction from pure observation ever conducted man) requires a slight modification when we come to the extreme nicety of numerical calculation." (Herschel's "Astronomy," p. 264, and note, p. 263.) I will not allow of modifications, however slight. When the so-called science is really exact, I shall give up every proposition that they fail to prove. When mathematical and chemical analysis, and dynamic demonstration and photometric nicety, shall have arrived at reality, I shall submit to their decision, but not till then—not till they are as real as geometric diagrams, or as true as the only immutable science, that of Numbers,—“the only remaining and widely diffused hieroglyphic”—indestructible hieroglyphic—of immutable truth!

“Numerical values are, indeed, the expression of physical laws; they show to us the constant amid change, the stable amid the flow of phenomena.”

And when all science, and especially *approximative* analysis, shall evolve their results in this pure divinity of exact Number—I shall then, indeed, acknowledge that they are exact sciences.

THE END.

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